

Fundamentals of Sericulture

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Rubia Bukhari

Rayees Ahmad Bhat



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Preface

To present the comprehensive and up to date information in this book “Fundamentals of Sericulture” we have drawn necessary information from the published books, documents, periodicals and help taken from all of them is gratefully acknowledged. We are deeply privileged and honoured by Prof. Dipanker Sen Gupta, (Director Poonch Campus, University of Jammu) for encouragement to publish the book and look for his blessings and encouragement in future. We deeply express our gratitude to Prof. Vinod Sharma, (Computer Science, University of Jammu) whose cooperation and involvement enabled us to prepare this book.

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Thorough efforts have been made to incorporate correct and authentic information; some errors might have crept inadvertently. Please bring out such errors to the notice of the authors and the publishers. Views and suggestions from users of this book are welcome to improve upon future editions. Suggestions for further improvement of the book will be gratefully acknowledged.

Authors

About the Authors

Dr. Rubia Bukhari, is working as Lecturer, in the Department of Sericulture, Poonch Campus, University of Jammu. She completed her Ph.D in Sericulture in 2019 from Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu. Before pursuing Ph.D, she completed her B.Ed. in 2015, and Masters in Sericulture in 2014 from University of Jammu. She is specialised in DNA fingerprinting, Gene manipulation, Silkworm Biotechnology, Silkworm breeding and Gene Expression. She was awarded Best Thesis Award in recognition of the consistent superior performance in sericulture for her doctoral thesis. She was also awarded IMRF Young Scientist Award in recognition of the consistent superior performance in sericulture in 2019. To her credits there are about 30 original research papers in reputed / referred national and international journals of India and overseas. She has teaching experience of over 1 year and has presented her research works in many National / International conferences and seminars. She has been serving as an eminent reviewer for 5 reputed Journals. She is the author of various articles, several Chapters in 3 books. She also writes frequently for various books, research papers and chapters. The author with her rural background and experience suggests Sericulture as an ideal industry suitable for enrichment of economic status of rural farming community and eradicate the problem of unemployment to the educated youth.

Dr. Rayees Ahmad Bhat is a research scholar in the field of Zoology and Reproductive Biology. He got his Ph.D in Zoology from Kurukshetra University, Kurukshetra. He has published a number of national and international publications; he has 4 book reviews in his credit. Besides this he has participated more than 10 national and international conferences/seminars. Dr. Rayees has published 10 books in the field of Zoology. He is also editorial member in a number of various reputed journals. Besides this he is an assistant editor and reviewer in many journals.

INTRODUCTION TO SERICULTURE

1.1 What is Sericulture, Geographical Distribution; Origin, History and Silk Route

Introduction

The word Sericulture is derived from Greek word 'sericos' meaning silk and 'culture' meaning rearing. It includes mulberry cultivation to produce leaf and silkworm rearing for the production of silk. Sericulture is an agro based industry, involving the raising of food plants for silkworm, rearing of silkworm for production of cocoons, reeling and spinning of cocoons for production of yarn etc., for value added benefits such as processing and weaving. Sericulture which includes the scientific method of raising the food plants, production of silkworm eggs, conservation and rearing of silkworm, culminating with the production and disposal of silk cocoons, is labour intensive, export oriented, employment creating an income generating agro based cottage industry providing quick returns in shorter duration and does not involve utilization of sophisticated machinery. The silk is the direct economy and product of sericulture activity. Besides, the utility of cocoons practically nothing gets waste in sericulture, the bi-products such as mulberry shoots serve as firewood and fuel, the left over leaves and excreta as cattle feed, manure and in the production of biogas, reeled out pupae and used male moths as poultry feed and in manufacturing of certain medicines and amino acids, mulberry roots and barks in preparing antihypertension drug etc. Sericulture is a cottage industry par excellence and is one of the most intensive sectors of the Indian

economy combining both agriculture and industry, which provides far means of livelihood to a large section of the population i.e., mulberry cultivator, co-operative rearer, silkworm seed producer, farmer cum rearer, reeler, twister, weaver, hand spinners of silk waste, traders, etc., and is the only cash crop in agriculture sector that gives returns within thirty days. This industry provides employment nearly to three million people in our country.

- » Sericulture plays a major role in rural employment, poverty alleviation and earning foreign exchange. A lot of entrepreneurial opportunities are available in various fields of sericulture. It is practiced in various states viz. Karnataka, Andhra Pradesh, Jammu and Kashmir, West Bengal and states like Madhya Pradesh and Maharashtra have also started practicing sericulture. The non-mulberry sericulture is practiced in Assam, Jharkhand, Orissa and Madhya Pradesh. More than six million people are involved in sericulture activities. It is necessary to upgrade the skills of the sericulturists to use the full potentialities of sericulture to produce qualitatively superior cocoons and to earn profitable income.
- » Sericulture provides gainful employment, economic development and improvement in the quality of life to the people in rural area and therefore it plays an important role in anti poverty programme and prevents migration of rural people to urban area in search of employment. Hence, several developing nations like China, India, Brazil, Thailand, Vietnam, Indonesia, Egypt, Iran, Sri Lanka, Philippines, Bangladesh, Nepal, Myanmar, Turkey, Papua New Guinea, Mexico, Uzbekistan and some of the African and Latin American countries have taken up Sericulture to provide employment to the people in rural area.

What is Sericulture

The word 'Sericulture' is derived from Greek word "sericos" meaning 'silk' and the English word "culture" means 'rearing'. Thus sericulture refers to the rearing of silk producing organisms in order to obtain silk from them in controlled environmental conditions. Mulberry sericulture involves the cultivation of mulberry to produce leaf, rearing of silkworm to convert leaf to cocoon, reeling of the cocoon to obtain silk yarn and weaving to convert yarn to fabrics. The process of cultivation of mulberry to produce leaf is called Mori-culture. Sericulture is a unique combination of art and science, which involves the cultivation of food plant to harvest quality leaves, rearing of silkworms for the conversion of leaf protein into silk protein in the form of protective shells called cocoons, softening of the cocoon shell through boiling in order to remove the gummy substance called sericin for unwinding of the thin silk filament from the hard shell by a process called reeling and finally utilization of silk fiber for the preparation of fabric by a process called weaving. So Sericulture is a multistage activity which involves the following components.

Sericulture and its Components

Silk producing insects are commonly referred to as serigenous insects. Commercial rearing of silk producing insects is called sericulture. It is an agro-based industry comprising three main components:

1. **Mori-culture:** Mulberry silkworm is a monophagous insect, which feed only on mulberry leaves. Mulberry includes a number of species and varieties. They differ in suitability for silkworm rearing because of their varying nutritious value and palatability for worm. Mulberry leaves are food of *Bombyx mori* L. Since, mulberry plants are deciduous, start rearing project in the spring or summer, when an adequate supply of fresh leaves are available. As rearing of silkworm on artificial diet, formulas of leaf powder and protein are not recommended for most of the commercial silkworm strains currently available. The silkworms that feed on mulberry leaves are known as mulberry silkworms whereas the silkworm that feed on other than mulberry plants are known as non-mulberry silkworms. Hence the rearing of silkworms involves cultivation of their host plants, which provide a regular supply of leaves. Worms are introduced through DFLs (Disease Free Laying's, *i.e.*, eggs) procured from a quality centre called grainage.
2. **Rearing:** It involves feeding of silkworm under controlled environmental conditions upto sudden stage in order to harvest good quality cocoons. The silkworms are actually larvae of the silkmoth. They are reared in specially made trays in rooms under controlled environmental conditions viz. temperature and humidity and regularly fed leaves of their preference. At a certain stage they encase themselves inside the cocoons by spinning out silk. These cocoons are made from a single filament of material secreted by the mature larvae and wrapped around itself for protection. These filaments upon hardening by air constitute silk.

Rearing is of two types:

- a. Chawki rearing
 - b. Late age rearing
- a. **Chawki rearing:** The rearing of young age silkworm upto 2nd moult is called Chawki Rearing. Rearing of young age silkworm under ideal environmental conditions, feeding nutritious and tender leaves will make the larvae grow robust and make more stress tolerant during the advance age of development. Larvae at the stage have less resistant to dryness. Therefore care should be taken to brush the larvae at the proper time. In Chawki rearing maintenance of high temperature and humidity is optimum. In newly hatched larvae, the body water content remains very low but it increases rapidly till the 2nd instar. They require high water content in mulberry leaves at this stage.

- b. Late age rearing:** The rearing of grown up silkworm from 3rd to 5th instar is termed as late age silkworm rearing. At this stage the silkworm attains an significant growth and development i.e. 133 times increases in body size, 125 times increases in body weight and normally 1000 times increases in silk gland weight. It is completed in 14 to 16 days. The late age silkworm cannot tolerate the high temperature high humidity and poor ventilation. They are voracious feeders i.e. they consume about 94% of total feed. The 4th instar larvae have relatively low resistance to infection and therefore they must be reared under hygienic conditions similar to those of young silkworm larvae.

After the completion of the rearing the silkworm starts to spin the silk thread over its body by the process known as spinning.

- 3. Spinning:** Silk is actually hardened silkworm saliva. When silk gland the nutrients from its feed which is digested. The larvae then starts spinning of the silk from the small spinneret on its lip, through which silk exude. The single strand of silk that forms the cocoon is about 1 mile long. The silkworm moves its head in figure 8 pattern and it spins a cocoon. When the cocoon is partially made you can see the head moving around inside, if you hold it up to light.
- 4. Silk reeling:** The removal of silk yarn from the cocoons is called reeling. The silk filaments produced by two silk glands are connected together by sericin. This is done by first cooking them in water to remove the gum, which holds it together, and then unwinding the filaments (reeling). Usually 8-10 cocoons are reeled together. The process of reeling involves the unwinding of the bave of cocoons. There are three methods for reeling: the charkha, the slightly more advanced cottage basin and the costly automatic machines. Prior to weaving, the raw silk is boiled in water to remove remaining gum, dyed and bleached, and then woven into the garment – usually on handloom. In some cases the woven cloth may be dyed and bleached.

Steps in silk reeling:

1. Stifling process
 2. Cocoon boiling
 3. Silk reeling
- 1. Stifling process:** This is pre-reeling process by which the pupae inside the cocoons are killed, without compromising on the quality of silk. Steam stifling is commonly practiced in pre-reeling process.
 - 2. Cocoon boiling:** Here the cocoons are boiled in water to soften the shell and also to dissolve the sericin gum for the purpose of smooth reeling.

3. **Silk reeling:** The process involves the unwinding of bave of cocoons. The reeling is done either in traditional ways or by modern techniques. The silk is obtained by brushing the undamaged cocoon to find the outside end of the filament. The silk filaments are than wound on a reel. One cocoon contains approximately 1,000 yards of silk filament. The silk at this stage is known as raw silk.

The silk produced after reeling is raw silk. The raw silk is a filament from which the gum are not yet been separated. Then after separating the gum from the silk the pure silk is obtained. This pure silk is used for weaving.

5. **Weaving:** It is a method of fabric production in which two distinct sets of yarns or threads are interlaced at right angles to form a fabric or cloth. This process involves the following pathway.

- » **Dyeing the thread:** The threads which we wound on large cardboard cones are usually undyed. Firstly we must measure off number of yards we need and makes skeins for dyeing. In weaving, the longitudinal threads are called Warp and the lateral threads are called Weft or Filling. The method in which these threads are inter-woven affects the characteristics of the cloth. The cloth is usually woven on loom, a device that holds the Warp threads in place while filling threads are passed through them. A fabric band which meets this definition of cloth can also be made using other methods, including tablet weaving, back-strap or other techniques without looms. The way the warp and filling threads interlaced with each other is called weave. Woven clothes can be plain (in one colour or simple pattern) or can be woven in decorative or artistic design.

The first two are agricultural and the last one is an industrial component. India has the monopoly of having all the varieties of silkworms thus producing four different types of silks viz. Mulberry silk, Tasar silk, Muga silk and Eri silk. Accordingly, sericulture is classified into Mulberry culture, Tasar culture, Muga culture and Eri culture. Mulberry silk is produced extensively in the States of Karnataka, West Bengal and Jammu & Kashmir. Similarly, Tasar silk worms are reared traditionally by the tribes of Madhya Pradesh, Bihar and Orissa; Muga and Eri silk are produced exclusively in Assam. The food plant of silkworms is Mulberry for producing Mulberry silk. Tasar silk producing silkworms feed on *Terminalia tomentosa*, and *Terminalia arjuna*. Similarly, Muga silk producing silkworms feed on salu or Som; Eri silk producing silkworms feed on castor (*Ricinus communis*).

Origin, History and Silk Route

Silk production from the insect Silkworm *Bombyx mori* L. has an interesting history. As per the Chinese records, silk was first discovered by Xilingji (Hsi-ling-chi), wife of China's 3rd Emperor, Huangdi (Hoang-Ti), in 2640 B.C. It is reported that the Empress while having tea in her garden under a mulberry tree, accidentally dropped a silkworm cocoon into her cup of tea. While trying to take it out, she was surprised to notice that the silk fiber could be loosened and unwound. The Empress could also notice white shiny worms eating leaves on the mulberry tree and encasing themselves inside white shiny cocoons. Later, she collected cocoons and could see that fibers from several cocoons could be twisted together to make a thread that was strong enough to be woven into a cloth. Thereafter, Hsi-ling chi discovered not only the means of raising silk worms, but also the manners of reeling silk and of employing it to make garments. This resulted in the establishment of silk industry in China where the source of silk was kept a top secret for more than 2000 years. Later, sericulture spread throughout China, and silk became a precious commodity, highly sought after by other countries. Demand for this exotic fabric eventually created the lucrative trade route, the historically famous Silk Road or Silk Route named after its most important commodity. This road helped in taking silk westward and bringing gold, silver and wool to the East. With the mulberry silk moth native to China, the Chinese had a monopoly on the world's silk production.

After 1200 B.C, China lost their monopoly in silk production as sericulture reached Japan through Korea and then to other countries. Chinese immigrants who had settled in Korea helped in the emergence of silk industry in Korea. During the third century B.C. Semiramus, a general of the Army of Empress Singu-Kongo, invaded and conquered Korea. Among his prisoners were some sericulturists whom he brought back to Japan. They helped in the establishment and growth of sericulture industry in Japan. Another story is that a Chinese princess married an Indian prince. She carried silkworm eggs/mulberry cocoons in her elaborate head dress. She disclosed the secret of raising silkworms thus, silk production spread to India. In 550 A.D. moth eggs and mulberry seeds were smuggled from China by two Nestorian monks, sent by Emperor Justinian-I and silk production began in Byzantium. The technique of sericulture spread throughout the Mediterranean countries during the 7th century AD and then to Africa, Spain and Sicily. During latter part of the 19th century, modern machinery, improved techniques and intensive research helped the growth of sericulture industry in Japan. At present, Japan, China, Korea, Italy, Soviet Union, France, Brazil and India are the chief silk producing countries in the World.

Countries to Learn Secret of Silk

- » **KOREA:** In spite of their secrecy, however, the Chinese were destined to lose their monopoly on silk production. Sericulture reached Korea around 200 BC, when waves of Chinese immigrants arrived there.
- » **JAPAN:** Then the secret of silk came to Japan it was said that during 300 B.C. there was a Japanese General named as Semiramus who Conquered Korea. Among his prisoners some were sericulturists whom he took to Japan and started sericulture in Japan.
- » **TIBET:** The Chinese could not keep their monopoly forever. The industry is said to have spread to Tibet when a Chinese princess, carrying silkworm eggs and mulberry tree seeds in her head apparel, married the king of Koten in Tibet.
- » **INDIA:** From Tibet the industry spread slowly to India and Persia. According to Western historians, mulberry-tree cultivation spread to India through Tibet during 140 BC and cultivation of mulberry trees, rearing of silkworms began in the areas flanking the Brahmaputra and Ganges rivers. According to some Indian scholars silkworms (*Bombyx mori* L.) were first domesticated in the foothills of the Himalayas. Evidences in ancient Sanskrit literature, reveals that certain kinds of wild silks were cultivated in India from time immemorial. When British came to India, the flourishing silk trade exploited and developed silk centers in many parts of the country. The Company exported large quantities of silk produced in West Bengal to England. The Company's monopoly was abolished in 1836 and the entire trade turned over to private enterprise, due to improper organized system the silk industry in West Bengal declined. By the time other silk producing states in the country viz. Jammu and Kashmir, Mysore have developed the industry. About two and half centuries ago silk was introduced into Karnataka by Tipu Sultan, the ruler of the State. Today it is the biggest silk producing centre in India.

Silk Route

Silk from china to other European and western countries spread through the famous road known as Silk Road/route. Silk route was a prestigious network, of trade linking the civilization of east represented by china with the civilization of west represented by Rome. Silk Road is 7000 miles long. Trade of silk grew under the Han Dynasty. The Chinese trade of silk was internally within the Empire. Caravans from the empire's interior would carry silk to western edges of the region. Often small central Asian tribes attack these caravans to capture the trader's valuable commodities. Han Dynasty extended its military defenses to central Asia to protect these caravans. Later on an alliance was made with the central Asian

tribes in order to extend silk trade which lead to the birth of Silk Road. Silk Road connects china with central Asia, northern India, Arab and Rome. It connects the yellow river valley to the Mediterranean Sea. Silk Road start from china (Asian) followed the Great Wall of China to west by passing the Takla makan desert then climbed over to Pamir mountain and passed through present day countries Iran, Iraq and Syria. The trading relation between the Chinese and the Indians grew stronger with Han Dynasty expansion into central Asia. Chinese would trade their silk with the Indians for precious stones and metals.



Figure 1: The great Silk Route and spread of Sericulture (Ancient) from China

1.2. Status of Mulberry and Non - Mulberry Sericulture in India and Other Countries

Sericulture in India

Silk is a way of life in India. Over thousands of years, it has become an inspirable part of Indian culture and tradition. No ritual is complete without silk being used as a wear in some form or the other. Silk is the undisputed queen of textiles over the centuries. Silk provides much needed work in several developing and labor rich countries. Sericulture is cultivated in Karnataka, West Bengal, Tamil Nadu, Andhra Pradesh, Jammu and Kashmir, Gujarat, Kerala, Maharashtra, Uttar Pradesh, Rajasthan, Bihar, Orissa etc. Though India is the second largest silk producer in the world after China, it accounts for just 5% of the global silk market, since

the bulk of Indian silk thread and silk cloth are consumed domestically. Germany is the largest consumer of Indian silk. The sericulture industry is land based as silkworm rearing involves over 700,000 farm families and is concentrated in the three southern states of Karnataka, Tamil Nadu and Andhra Pradesh. The states of Assam and West Bengal are also involved in the industry to a certain extent. Silk, the queen of the fabrics still commands passion of consumer right from 2200 B. C till today, nationally and internationally. The export potential of Indian Sericulture Industry is evident from the fact that the annual export is Rs. 2879.56 crores during the year 2004-05. The Central Silk Board, Ministry of textiles, Govt. of India has been acting as a facilitator for planning, development and monitoring of Sericulture industry between the states and Central govt. The subject of research is the exclusivity of the Central Silk Board and its sub-ordinate Research and Training Institutes.

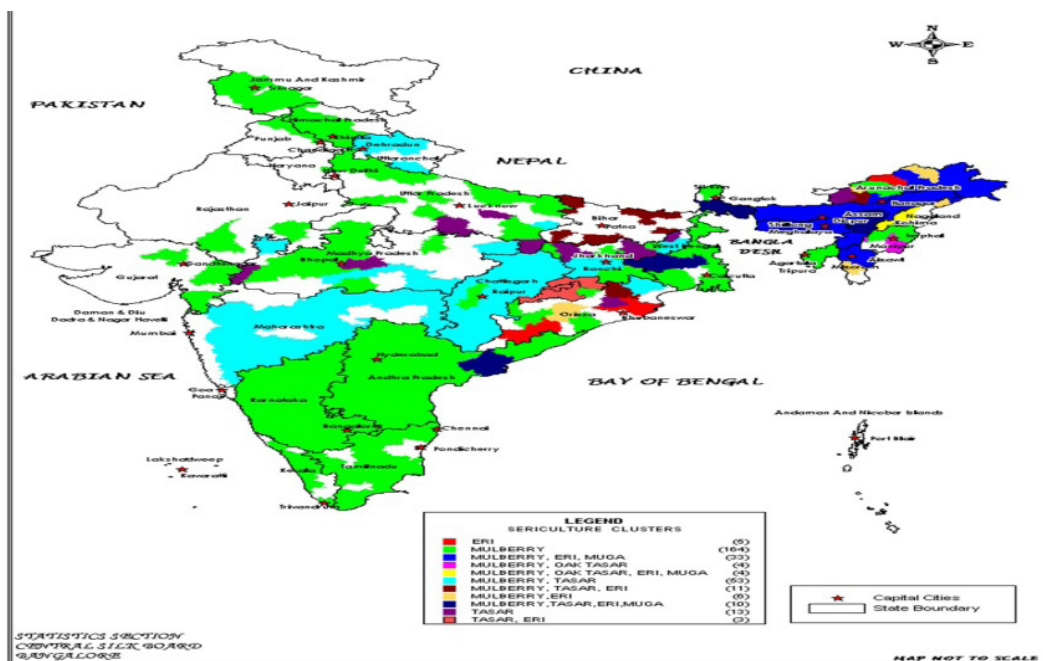


Figure 2: Sericulture map of India

World Production of Silk

Silk is a natural fiber. It is one of the most expensive and demanded fibers in the world. Silk is believed to be one of the finest fibers in the world. It is used to prepare clothes for different purposes. Silk attire is very famous for its glazy texture and bright outlook. This silk is been produced in many countries in the world. People breed the silkworm to produce silk for business purposes. These silk clothes are used for different purposes like in costumes, bed covers, and table covers. Some of the top 20 largest producers of silk in the world 2018 are:

Table 1: Global silk production (in metric tonnes) (All silk varieties put together)

Country	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	Share %
China	104000	126000	130000	146000	170000	158400	82.20
India	23060	23679	26480	28708	28523	30348	15.74
Uzbekistan	940	940	980	1100	1200	1256	0.65
Thailand	655	655	680	692	698	712	0.36
Brazil	558	614	550	560	600	650	0.33
Vietnam	500	450	475	420	450	523	0.27
North Korea	300	300	300	320	350	365	0.18
Iran	120	123	123	110	120	125	0.06
Bangladesh	38	42	43	44	44	44	0.022
Japan	42	30	30	30	30	32	0.016
Turkey	22	22	25	32	30	32	0.016
Others	29	35	16	32	28	205	0.10
Total	130264	152890	159702	178048	202073	192692	

The major silk producing countries in the world are: China, India, Uzbekistan, Brazil, Japan, North Korea, Thailand, Vietnam, South Korea, Iran etc. Few other countries are also engaged in the production of cocoons and raw silk in negligible quantities; Bangladesh, Japan, Turkey, Egypt etc.

Even though silk has a small percentage of the global textile market- less than 0.2%, its production base is spread over 60 countries in the world. While the major producers are in Asia, sericulture industries have been lately established in Brazil, Bulgaria and Egypt as well. Sericulture is a labour intensive activity. About 1 million workers are employed in the silk sector in china. Silk industry provides employment to 7.9 million people in India, and 20,000 weaving families in Thailand.

- » **CHINA:** The mighty leader: It is well known that silk was first discovered in china in the year 2852 B.C. by Shi Lin Chi wife of first Chinese emperor. China is the mightiest player in world silk market and is the largest producer of raw silk. China, accounts for 85% of global silk production with an annual output of 75000 MT. China with an output of about 146000 MT of superior quality raw silk with international standards. The reason for the superior quality of Chinese silk is attributed with the ideal climatic condition for the production of bi-voltine silk. China produces various grades of raw silk ranging from A grade - G grade of which most of the higher

grades are exported to European countries like Italy Switzerland and UK, mostly lower grades are exported to Asian countries mainly India, Taiwan etc. China is a member of ISA and the development of china's silk industry is closely linked to the development of the world silk business. In the past two years, silk production in china has increased with further expansion of mulberry farms.

- » **INDIA:** India also has a long history of developing silk in the world. Silk is called as resham in northern and east part of the country. The recent archaeological survey suggests that the production of wild silk has also been evidenced in the ancient Indus valley Civilization in the southern region in Asia. India is the second largest producers of silk and contributes about 14% raw silk production in the world. Different Indian states are known for their high-quality silk products. India is a huge market for quality silk production in the world.
- » **UZBEKISTAN:** Though the world has reached a level where the silk production is an automated process, in spite of that, Uzbekistan is a country where the breeding of silkworm still take place and they use the traditional method of developing silk in certain parts of the country even today. The world market gets a huge number of silk productions from the country. It has been consistency been one of the largest silk producing companies of the world. This country contributes to a large part of the raw as well as complete silk products. The quality of the produced silk by this country is trusted and globally recognized.
- » **BRAZIL:** Brazil is one of the largest producers of the silk in South American continent. The silk producing industries have grown over the time in the country. The country has reached a technological level, which they now produce the finest form of silk. Brazil is the only country outside Asian countries which has a steady growth in the silk producing sector. Brazil is growing at a fast pace in producing silk in the world. This country is one of the largest producers of the world.
- » **THAILAND:** Thailand is one of the countries to produce silk throughout the year. Thailand contributes to a large part of world's silk production and it is a constant and huge producer of the world. Thailand has one of the best quality silk productions. Thai silk is produced from the cocoons of Thai silkworms. Thailand's silkworm farmers cultivate both types of the domesticated silkworms that produce commercial silk; *Samia ricini*, commonly known as the Eri silkworm, which produces Eri silk, and the *Bombyx mori* L. producer of the better known, glossy mulberry silk.
- » **KOREA:** With regard to evidence of silk manufacture in Korea proper, perfectly preserved silk threads were found in a coffin in a tomb at Dahori, South Korea, dating from the first century B.C. This confirms references in the Wei chronicle to the people of southern Korea tending mulberry trees and silk worms and producing

silk material. At various archeological sites near Pyongyang, tabby silk, gauze silk and lacquered silk were found by Japanese excavators, who claimed that they were from the Lolang period under Han dynasty rule. However, from old place names within Korea proper such as Jamdae, meaning “silk place,” we may conclude that sericulture must have been a native Korean industry.

- » **SOUTH KOREA:** South Korea is a fast-growing country for the production of silk fiber in the world. Rwanda is the company which is well known for the development of silk. The culture of sericulture is growing in the country and it is also creating a great impact on the global market. South Korea has become the largest producer of silk in the world, and it has captured a large part of the world market with the quality products it produces.
- » **JAPAN:** Japan is an established hub for the industrial sector. With all the other industries its silk developing industry is also growing with time and has reached a level to acquire international recognition. Japanese silk has a large hold over the international market. This country is one of the largest producers of silk to the global market. The product from Japan is highly demanded by the global costumers also. The Japanese silk has been able to win the trust of the customer worldwide and has been able to reach every corner of the world.
- » **SRI LANKA:** In 1976 sericulture industry in Sri Lanka came under a separate authority, The Silk and Allied Products Development Authority known as SAPDA. The functions of the SAPDA were to promote and develop sericulture and to regulate the industry in Sri Lanka. SAPDA was the only raw silk producer in the country, with four farms and several clusters of small holdings which belonged to the farmers in the rural areas. SAPDA had established a filature about 125 kilometers from Colombo. The Government of Sri Lanka noted repeatedly the great potential for the industry in view of favorable agro climatic factors and the plentiful availability of rural labour at low cost, with a relatively high level of education and literacy. The tropical climate permitted sericulture practiced throughout the year with continuous growth of mulberry enabling multiple cropping and year-round production of cocoon. The national silkworm breeding stock comprised of 46 pure lines, including multivoltine, bivoltine and univoltine races introduced from Japan, Korea and India. The stocks maintained by the silkworm breeding centre at Nillambe under SAPDA. The breeding was carried out successfully. The country was self-sufficient in the supply of silkworm eggs.

Present Status of Silk Production; Raw Silk Imports and Raw Silk Exports

Silk is the most elegant textile in the world with unparalleled grandeur, natural sheen, and inherent affinity for dyes, high absorbance, light weight, soft touch and high in durability. Because of these unique features silk is known as the “**Queen of Textiles**” the world over. On the other hand, it stands for livelihood opportunity for millions, owing to its high employment potential, low capital requirement and remunerative nature of its production. The very nature of this industry with its rural based on-farm and off-farm activities and enormous employment generation potential has attracted the attention of the planners and policy makers to recognize the industry among one of the most appropriate avenues for socio-economic development of a largely agrarian economy of India. Silk has been intermingled with the life and culture of the Indians. India has a rich and complex history in silk production and its silk trade which dates back to 15th century. Sericulture industry provides employment to approximately 8.25 million persons in rural and semi-urban areas in India. Of these, a sizeable number of workers belong to the economically weaker sections of society, including women. India’s traditional and culture bound domestic market and an amazing diversity of silk garments that reflect geographic specificity has helped the country to achieve a leading position in silk industry. India has the unique distinction of being the only country producing all the five known commercial 26 silks, namely, Mulberry, Tropical Tasar, Oak Tasar, Eri and Muga, of which Muga which is produced only in India with its golden yellow glitter is a prerogative of India. India is the second largest producer of silk in the World. Among the four varieties of silk produced in 2016-17, Mulberry accounts for 70.09% (21,273 MT), Tasar 10.77% (3,268 MT), Eri 18.58% (5,637 MT) and Muga 0.56% (170 MT) of the total raw silk production of 30,348 MT.

Table 2: Performance of Sericulture Sector

Particulars	2015-16 Achmnt.	2016-17		2017-18	
		Target	Achmnt.	Target	Achmnt. (P) (Till Nov- 17)
Mulberry Plantation (Lakh ha.)	2.09	2.27	2.17	2.41	2.32
Raw Silk Production					
Mulberry (Bi-voltine)	4,613	5,260	5,266	6200	3689
Mulberry (Cross breed)	15,865	17,400	16,007	17276	10552
Sub Total (Mulberry)	20,478	22,660	21,273	23,476	14,241
Vanya					
Tasar	2,819	3,285	3,268	3450	1423

Eri	5,060	5,835	5,637	6675	4,172
Muga	166	220	170	240	118
Sub Total (Vanya)	8,045	9,340	9,075	10,365	5,713
GRAND TOTAL	28,523	32,000	30,348	33,840	19,954

Source: The data received from DOSs and compiled at CSB (Central office) P: provisional

Production during 2016-17 and 2017-18 (up to November 2017)

During 2016-17, the total raw silk production in the country was 30,348 MT, which is an increase of 6.4% over the production achieved during the last year and around 94.8% of the annual targeted production for the year 2016-17. The mulberry silk production was 3.8% more during 2016-17 over the last year. The bivoltine raw silk production achieved a record production of 5,266 MT during 2016-17 by registering 14.2% growth over previous year. Similarly, Vanya silk, which includes; Tasar, Eri and Muga raw silks, has achieved 12.8% growth during 2016-17 over 2015-16. The area under mulberry during 2016-17 was up by 3.9% The State-wise production of Raw silk during the years 2013-14 to 2016-17 and for the year 2017-18 (Till November-17) are given in the Table below:

Table 3. State wise Raw Silk production during the last 5 Years (2013-14 to 2017-18)

S. No.	State	2013-14	2014-15		2015-16		2016-17		2017-18 (P) (Till Nov.-17)	
		Achmnt.	Target	Achmnt.	Target	Achmnt.	Target	Achmnt.	Target	Achmnt.
1	Karnataka	8574	8850	9645	10000	9823	11000	9571	11120	5962
2	Andhra Pradesh	6912	6458	6485	5700	5086	5505	5970	6090	4466
3	Telangana		87	101	50	116	150	119	160	56
4	Tamil Nadu	1120	1739	1602	1920	1898	2000	1914	2000	1307
5	Kerala	4	6	7	9	11	10	11	12	6
6	Maharashtra	122	378	221	250	274	285	259	328	184
7	Uttar Pradesh	188	152	236	257	256	280	269	300	147
8	Madhya Pradesh	195	222	248	215	257	275	111	230	25
9	Chhattisgarh	391	301	234	253	263	290	361	405	401
10	West Bengal	2079	2417	2500	2567	2391	2706	2565	2590	1628
11	Bihar	52	74	53	65	67	84	77	85	9
12	Jharkhand	2003	2197	1946	2210	2284	2624	2631	2744	990
13	Orissa	53	111	98	120	117	130	125	140	16
14	Jammu & Kashmir	136	217	138	135	127	170	145	180	132

15	Himachal Pradesh	25	40	30	30	32	40	32	40	25
16	Uttarakhand	22	37	29	30	30	38	34	44	19
17	Haryana	0.13	2	0.3	1	0.6	2	1	2	0.43
18	Punjab	4	14	4	1	0.8	5	3	6	3
19	Assam & Bodoland	2766	2939	3222	3810	3325	4103	3811	4705	2723
20	Arunachal Pradesh	15	38	12	40	37	48	45	58	46
21	Manipur	487	737	516	560	519	503	529	560	243
22	Meghalaya	644	776	656	835	857	900	927	1070	986
23	Mizoram	44	54	50	65	64	82	76	100	81
24	Nagaland	606	599	619	715	631	690	678	770	450
25	Sikkim	0.20	13	8	7	6	16	9	17	-
26	Tripura	40	43	48	56	52	65	75	85	48
Total		26,480	28,500	28,708	30,000	28,523	32,000	30,348	33,840	19,954

Raw Silk Imports: The quantity and value of raw silk imported during years 2014-15 to 2016-17 and for the year 2017-18 (till November-17) are given below:

Table 4: Quantity and value of Raw Silk imported during Years 2014-15 to 2016-17

Years	Quantity (MT)	Value (Rs. in Crores)
2014-15	3489	970.82
2015-16	3529	1006.16
2016-17	3795	1092.26
2017-18*	2669	835.90

Source: DGCIS, Kolkata. *Figure indicated for the period of April-November 2017 (Provisional)

Raw Silk Exports: The silk goods export earnings have been decreased over the years due to global recession and reduction in demand for silk goods in western countries (Western Europe and the USA, which are the major consumers of silk goods). However, the silk exports are picking up to the non-traditional/new markets such as the UAE, Nigeria, Sudan, Thailand etc., which is an encouraging sign. The export earnings during 2016-17 were Rs. 2,093.42 crores. Export values of silk goods during the last 3 years 2015-16 and 2016-17 and for the year 2017-18 (till Nov.'17) are given below:

Table 5: Export values of silk goods during the last 3 years 2015-16 & 2016-17 and for the year 2017-18 (till Nov'17)

(Rs. in Crores)			
Items	2015-16	2016-17	2017-18 (April 17 to Nov. 17)
Natural Silk Yarn	30.31	15.33	3.23
Silk Fabrics	1280.60	1051.65	231.09
Readymade Garments	1078.39	864.33	638.57
Silk Carpet	16.88	63.78	7.25
Silk Waste	89.80	98.33	60.58
Total	2495.98	2093.42	940.72

Source: FTSI and MSFTI, DGCIS.

Employment Generation:

The employment generation in the country is raised to 8.51 million persons in 2016-17 compared to 8.25 million persons in 2015-16, indicating a growth of 3.15%.

1.3 Background, Current Scenario and Future Challenges of the Indian Silk Industry

Indian Textile Industry

A Brief History

India is well known for its textile goods from very ancient times. The traditional textile industry of India was virtually decayed during the colonial regime. However, the modern textile industry took its birth in India in the early nineteenth century when the first textile mill in the country was established at Fort Gloster near Calcutta in 1818. The cotton textile industry made its real beginning in Bombay, in 1850s. The first cotton textile mill of Bombay was established in 1854. From its inception, the industry passed through vicissitude of fortune till it reached its present status. As the industry grew up, the yarn trade with China fetched it good profit. The Indian market was not favourable initially, because of competition with Lancashire goods, but the natural advantages of humid climate, raw materials and an external market helped the growth of the industry considerably. During the later part of the last century, Japan became a rival to India in yarn trade with China and the Far Eastern Asia. During the First World War (1914-1918), Japan obtained better opportunities for marketing her yarn in China (Roy, 1996).

India was dependent considerably on the United Kingdom for the supply of machinery, caustic soda, bleaching powder, etc., for her cotton mills. The home market was not favourable to the industry because of competition with Lancashire fabrics which poured into India in large quantities. Production of yarn was more profitable than the production of cloth, since yarn could be marketed outside. Railway freight charges in India for transporting coal to the cotton mills were high as the coal had to be obtained from the Damodar Valley, the only important coal producing area in the country. It was, therefore, more profitable to import coal from South Africa by sea route for the cotton mills in India. This situation continued till water power was developed in Bombay and other areas in the early part of the 20th century.

The two world wars and the Swadeshi movement provided great stimulus to the Indian cotton textile industry. However, during the period 1922 to 1937 the industry was in doldrums and during this period a number of Bombay mills changed hands. The Second World War, during which textile import from Japan completely stopped, however, brought about an unprecedented growth in this industry. The number of mills increased from 178 with 4.05 lakh looms in 1901 to 249 mills with 13.35 lakh looms in 1921 and further to 396 mills with over 20 lakh looms in 1941. Thus by 1945, there were 417 mills employing 5.10 lakh workers (Sastry, 1984).

Structure of the Indian Textile Industry

The textile sector in India is one of the world's largest industries. It is divided into three segments:

1. Cotton textiles
2. Synthetic textiles
3. Others like wool, jute and silk

All segments have their own place but, even today, cotton textiles continue to dominate with 73 per cent share. The structure of the textile industry is extremely complex with the modern, sophisticated and highly mechanized mill sector on the one hand and hand spinning and hand weaving (handloom sector) on the other; in between falls the decentralised small scale power-loom sector. Unlike other major textile-producing countries, India's textile industry is comprised mostly of small-scale, nonintegrated spinning, weaving, finishing, and apparel-making enterprises. This unique industrial structure is primarily a legacy of government policies that have promoted labour-intensive, small-scale operations and discriminated against larger scale firms (Rangarajan, 2005).

Emerging or Current Scenario of Indian Silk Industry

The Indian silk industry is passing through a crucial phase of reorientation and adjustment necessitated by the market forces. Therefore, at this juncture, it will be interesting to examine the extent to which different production and marketing system of the industry are capable of absorbing the changing market signals. It is also necessary to examine to what extent the output of the industry has been changing in terms of quantity and structure as a result of the changing demand patterns. This study addresses itself to some of these important issues relating to the post cocoon sector of the industry.

The silk industry has a distinctive position in India that plays a significant role in textile industry and export. India is the 2nd largest producer of silk in the world with 23060 metric tonnes (MT) (2011-12) and also the largest consumer of silk in the world and contributes 15 per cent of the total world raw silk production. Geographically, Asia is the main producer of silk in the world and manufactures over 95 per cent of the total global output. Although there are over 40 countries on the world map of that produce silk, bulk of it is produced in China and India, followed by Japan, Brazil and Korea. China is the leading supplier of silk to the world with an annual production of 1,24,000 MT (2011-12), out of which the Mulberry raw silk production is 90,980 MT.

Indian Silk Industry

Silk is a lustrous, tough, elastic fibre produced by the larvae of silkworms; the term also covers the thread or cloth made from this fibre. The silk industry originated in China, as early as 2640 BC according to tradition. Towards the 3rd century AD, knowledge of the silkworm and its product reached Japan through Korea; it probably spread to India a little later. India is the largest consumer of silk in the world. Silk is a unique fabric which has gradually crept in everybody's home in some way or the other. The Indian silk industry is an integral part of the Indian textile industry and is among the oldest industries in India. It engages around 60 lakh workers and it involves small and marginal farmers. Indian silk industry is the second highest contribution of silk to the world production. Consistent market demand and remarkable approach has led to the widening of this industry (Bhushi and Pharsiyawar, 2004).

Silk is mainly produced in Pochampally, Kanchipuram, Dharmavaram, Mysore, etc., in South India and Banaras in the North for manufacturing garments and sarees. "Murshidabad silk", famous from historical times, is mainly produced in Malda and Murshidabad districts of West Bengal and woven with hand looms in Birbhum and Murshidabad districts. Another place famous for production of silk is Bhagalpur. The silk from Pochampally is particularly well known for its classic designs and enduring quality. The silk is traditionally hand-woven and hand-dyed and also usually has silver threads woven into the cloth (Sastry, 1984).

Among the four varieties of silk produced, in 2014-15, Mulberry accounts for 74.51% (21,390 MT), Tasar 8.5% (2,434 MT), Eri 16.5% (4,726 MT) and Muga 0.55% (158 MT) of the total raw silk production of 28708 MT. Production of raw silk in India during the year 2015-16 (April to August- 2015) has been 9,590 MT in which, mulberry and Vanya raw silk output amounts to 7,053 MT and 2,537 MT, respectively.

India is the 2nd largest producer of silk and contributing about 18% of the world production. The silk industry today in India employs over 70, 00,000 farm families. Silk industry occupies a unique position in India. Sericulture is an important cottage industry in India. India is a labour intensive industry operating on around 54,000 villages all over the country. An assortment of silk varieties such as Mulberry, Eri, Muga, Tasar etc. are grown. This industry is generous enough providing job opportunities and livelihood for more than six million people in rural area. 60 Lakh workers engage in silk industry in India. In India 97% of raw silk is produce in 5 Indian states i.e., Karnataka, Andhra Pradesh, Tamil Nadu, West Bengal and Jammu and Kashmir. All these 5 states are traditional states.

1. Silk industry in Karnataka

Karnataka is known as “silk bowl of India” and is the largest producer of silk. It provide jobs for around 10.7 Lakh people of Karnataka as well as establish Multi-voltine seed and contribute about 70 % of total raw silk production. Karnataka produce 9,000 metric tons of mulberry silk of a total 14,000 metric tonnes produced in the country. The area under mulberry plantation is 87,598 square feet. In Karnataka silk is mainly grown in Mysore district. The area under cultivation is 8500 hectare. Bulk of production comes from district Bangalore, Kolar Mysore and Pampore etc., presently about 16,593 villages are involved in sericulture.

2. Silk industry in Andhra Pradesh

Andhra Pradesh is the second largest producer of silk in India. Andhra Pradesh achieved significant place in the development of sericulture. The area under mulberry plantation is 29,829 feet. India has been raised up to 90.8 thousand hectare area for mulberry cultivation under irrigated condition. Sericulture is carried in almost all the district but area like Crime nagar, Chittoor, Visakhapatnam and Anantpur are largest contributor. Beside silkworm rearing and cultivation Andhra Pradesh produce more than one Lakh hand looms and the state sericulture department has developed a various resistant transgenic silk worm.

3. Silk industry in Tamil Nadu

Tamil Nadu is the 3rd largest producer in India. The area under mulberry plantation is 16,160 hectare. The industry is spread all over the state but more particularly Salem and Maduri. The latest cost saving technical most institutes by state sericulture department in research institute, help the farmer to increase their production. CSB and state sericulture department also provide infra structure for the development of sericulture industry in the state.

4. Silk industry in West Bengal

West Bengal is the 4th largest producer of raw silk in India. The area under mulberry plantation is 15,500 feet. The state has more than 4500 hand looms with important weaving centers and the reeling work is done on the traditional charkhas. The state has silk conditioning house at Kolkata and 100 Basin creatures' filatures at Madhughat. The district contributes silk production to Malda district, Murshidabad, Baswa, Bankpura, Chak Islampur etc. West Bengal occupies 53911 acres land cultivation out of which 26533 acres of land has been planted with high yielding variety of mulberry.

Table 6: Mulberry Plantation in India

States	Mulberry plantation (hectare)	Mulberry raw silk (MT.) Bivoltine hybrids	Mulberry raw silk (MT.) Cross breed	Total
Karnataka	87598	1344	8479	9823
Andhra Pradesh	29829	708	4378	5086
Tamil Nadu	16160	1532	366	1898
West Bengal	15500	31	2320	2351
Jammu and Kashmir	8237	127	-----	127

Table 7: Mulberry Plantation and Raw Silk production in India

States	Mulberry plantation (Hectare)	Mulberry Raw Silk (MT)			Vanya Raw Silk (MT)				Total (M+V) (MT)
		Bivoltine hybrids	Cross Breed	Total	Tasar	Eri	Muga		Total
Andhra Pradesh	29829	708	4378	5086	---	---	---	---	5086
Jammu and Kashmir	8237	127	---	127	---	---	---	---	127
Karnataka	87598	1344	8479	9823	---	---	---	---	9823
Tamil Nadu	16160	1532	366	1898	---	---	---	---	1898
West Bengal	15500	31	2320	2351	34	6	0.21	40	2391

5. Silk Industry in Jammu and Kashmir

Jammu and Kashmir is the 5th largest silk producer in India. It is the traditional state for silk production. The climate of the state is best suited for silkworm rearing. In Kashmir division two crops are easily rear while in Jammu 3 to 4 crops can be grown. The sericulture provides employment of 52,000 families as part time and 5,000 families as full time. The total production is 137 metric tonnes. Both CSB and state Govt. pay attention for silkworm rearing for the production of silk. The state produce white plan silk known as tabby and the state has about 100 hand looms and 150 power looms used for reeling and weaving. The main producer of J&K is Rajouri, Anantnag, Baramula, Srinagar, Doda, Jammu, Reasi, Udhampur and Poonch. These districts produce approximately 28 tonnes of raw silk. On date 21 Jan 2017 the Govt. said that the current production of cocoon is 973 metric tonnes in Jammu and Kashmir. The area under mulberry plantation is 4717 sq ft. In J and K there are 2500 sericulture villages. Udhampur becomes highest cocoon producing district in J&K according to daily excelsior on 20th of August 2016. In J&K there are 294000 rearers. The production of silk in Jammu and Kashmir in 2015-16 is about 127 MT.

Table 8: Data of J and K

Mulberry sector	
Number of departmental nurseries	173
Total area of nurseries	963 acres
Production capacity of saplings / year	30 lac
Present annual sapling production in departmental nurseries	15 lac
Total available mulberry wealth in the state	110 lac trees
Seed sector	
Number of grainages	6 numbers
Basic seed stations	9 numbers
Annual disease free laying's production	17 lac
Annual disease free laying's consumption	29 lac
Commercial silkworm rearing	
Numbers of rearers	29400
Number of sericulture villages	2800
Annual cocoon production (MT)	1105
Income generation (lac)	2226
Post cocoon sector	
Number of rearing units	37 (14 functional)

Source: Annual report Sericulture Development Department Jammu and Kashmir- 2016-17.

Table 9: Number of sericulture villages in Jammu and Kashmir

Years	Number of Sericulture Villages
2010-11	2450
2011-12	2500
2012-13	2628
2013-14	2628
2014-15	2700
2015-16	2836

Source: Economic survey 2015-16, government of Jammu and Kashmir.

Table 10: Rearers' population during last few years

Years	Number of Rearers
2010-11	22700
2011-12	25000
2012-13	27000
2013-14	28000
2014-15	29400
2015-16	31882

Source: Annual report Sericulture Development Department Jammu and Kashmir, 2016-17.

Table 11: Cocoon production during last few years

Period	Cocoon production (MT)	Productivity per oz (Kg)
2010-11	810	31.00
2011-12	860	32.00
2012-13	917	33.00
2013-14	901	32.00
2014-15	1022	34.00
2015-16	1105	42.00

Source: Annual report Sericulture Development Department Jammu and Kashmir, 2016-17.

1.4 Strengths of Sericulture Industry; Problems of Indian Sericulture Industry; Characteristics of Sericulture Industry; International Demand of Silk and Constrains in Silk Production Like Labour, Land and Environmental Conditions and Scope of Sericulture

Sericulture has been identified as an occupation of low investments, employment creating and income generating. It has been found that sericulture is highly profitable as compared to many other crops. Sericulture involves simple technologies, easy to understand and adopt even by illiterate farmers and it gives returns in quick succession yielding income in every two or three months. Sericulture does not involve hard labour and rearing of silkworms is generally attended to by women and old people. Sericulture does not require sophisticated machinery and it involves use of simple appliances. Mulberry plants can be grown in any type of soil even in forest fringes, hill slopes and watershed areas. Sericulture ideally suits even in rain fed conditions because of its low cost of production and higher returns than any other crop. Mulberry plant withstands severe drought conditions and gives at least some income for sustenance while other agriculture crops wither away. Sericulture would be a more advantageous industry for improving the economy of retarded section of the society like scheduled caste and scheduled tribes. Non- mulberry sericulture is largely practiced by the tribals. Sericulture ideally suits small and marginal farmers.

In developing countries like India, agriculture and agro-based industries play a vital role in the improvement of rural economy. The limited availability of land, the limited cash returns, and agriculture being confined to one or two seasons in the year, have made villages to look for supporting rural industries, such as sericulture. Agriculture and sericulture are adopted simultaneously by the agriculturists in regions where the ecological conditions are favourable. In India, over three million people are employed in various fields of sericulture. It is a cottage industry and provides ample work for the womenfolk in the rural areas in rearing silk worms, while the male members work in the fields. Recently the enforcing of new ideas by research institutions both in mulberry cultivation and silk-worm-handling among sericulturists, the industry is now practiced as a main profession and as a major cash crop of the country.

The strengths of silk industry can be summarized as follows:

- » Enormous production capacity
- » Efficient raw material manufacturing capacity
- » Large pool of skilled and cheap labor
- » Entrepreneurial skills

- » Enormous export potential
- » Large domestic market
- » Very low import content
- » Flexible silk manufacturing systems

The strength of this industry lies in its wide base, the sustaining market demand pull especially from the Indian handloom weaving sector, the infrastructure created by the national sericulture project and the research and training capabilities.

Problems of Indian Sericulture Industry

Though sericulture is ideally suited for improving the rural economy of the country, as it is practiced as a subsidiary industry to agriculture, it is hindered by various factors like imports of cheap and alternative textiles from other Asian neighbours, use of outdated manufacturing technology, primitive and unscientific “reeling” and “weaving” techniques, use of poor quality seeds, low production of bi-voltine seeds, use of non-graded and diseased seeds, poor knowledge of farm disease amongst farmers, poor supply chain management, huge unorganized and decentralized sector, high production cost, recurring droughts and increased import of silk from China and accompanied with the following problems like:

1. Price fluctuation
2. Absence of proper market
3. Long distance to market
4. Lack of transport facilities
5. Absence of storage facilities
6. Poor information on market trend.
7. Lack of finance

Characteristics of Sericulture Industry

Silk is nature's gift to mankind a commercial fiber of animal origin other than wool. Being an eco-friendly biodegradable and self sustaining material, silk has assured special relevance in present age. Promotion of sericulture can help in ecosystem development as well as high economic returns.

- » Sericulture is a small scale, agro-based cottage industry and labour intensive industry.
- » It is a textile industry and it substitutes the cotton industry.

- » Fine delicate clothes are prepared from silk threads.
 - » The fiber of silk is most lustrous.
 - » The silkworm has three types of silks;
1. Uni-voltine silk: Uni-voltine silk is of superior quality.
 2. Bi-voltine silk: Bi-voltine silk is inferior in quality than Uni-voltine.
 3. Multi-voltine silk: Multi-voltine silk is inferior to all other silk types.
 - » Silk is one of the oldest known textile fibre and according to Chinese tradition, was used as long ago as 27th century BC.
 - » Silkworm, common name for silk producing of larvae of any of several species of moths.
 - » Silkworm posses a pair of specially modified salivary glands called silk glands.

Why Sericulture is important?

1. High employment potential

- » 80 lakh persons are engaged in various sericulture activities in the country.
- » It is estimated that Sericulture can generate employment @ 11 man days per kg of raw silk production (in on-farm and off-farm activities) throughout the year. This potential is par-excellence and no other industry generates this kind of employment, specially in rural areas, hence, sericulture is used as a tool for rural reconstruction.



Figure 3: Men working in reeling section

2. Provides vibrancy to village economies

- » About 57 % of the gross value of silk fabrics flows back to the cocoon growers with share of income to different groups.
- » 56.8 % to cocoon grower
- » 6.8% to the reeler
- » 9.1% to the twister
- » 10.7% to the weaver
- » 16.6% to the trade
- » Thus, large chunk of income goes back to the villages from the cities.

3. Low gestation, high returns

- » Estimated investments of Rs. 15,000 (excluding cost of land and rearing space) is sufficient for undertaking mulberry cultivation and silkworm rearing in one acre of irrigated land.
- » Mulberry takes only 4-6 months to grow for commencement of silkworm rearing. Mulberry once planted will go on supporting silkworm rearing year after year for 15-20 years depending on inputs and management provided.
- » Five crops can be taken in one year under tropical conditions.
- » By adopting stipulated package of practices, a farmer can attain net income levels up to Rs. 1, 00,000 per acre per annum from next year it could be more as mulberry leaf grows double.

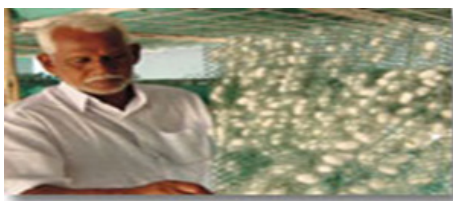


Figure 4: Farmer showing his cocoon crops

4. Women friendly occupation

- » Women constitute over 60 % of those employed in down-stream activities of sericulture in the country. This is possible because sericulture activities starting

from mulberry garden management, leaf harvesting and silkworm rearing is more effectively taken up by the women folk. Even silk reeling industry including weaving is largely supported by them.



Figure 5: Women's working in rearing house

5. Ideal programme for weaker sections of the society

- » Sericulture can be practiced even with very low land holding.
- » Acre of mulberry garden and silkworm rearing can support a family of three without hiring labour.
- » Features such as low gestation, high returns make sericulture an ideal programme for weaker sections of the society.

6. Eco-friendly activity

- » As a perennial crop with good foliage and root-spread, mulberry contributes to soil conservation and provides green cover.
- » Waste from silkworm rearing can be recycled as inputs to garden.
- » Dried mulberry twigs and branches are used as fuel in place of firewood and therefore reduce the pressure on vegetation/forest.
- » Being a labour intensive and predominantly agro-based activity, involvement of smoke-emitting machinery is minimal.
- » Developmental programmes initiated for mulberry plantation are mainly in upland areas where un-used cultivable land is made productive.
- » Mulberry can also be cultivated as intercrop with numerous plantations.
- » Mulberry being a deep-rooted perennial plant can be raised in vacant lands, hill slopes and watershed areas.
- » Currently, 2.19 lakh Hectare land in the country is under mulberry cultivation.

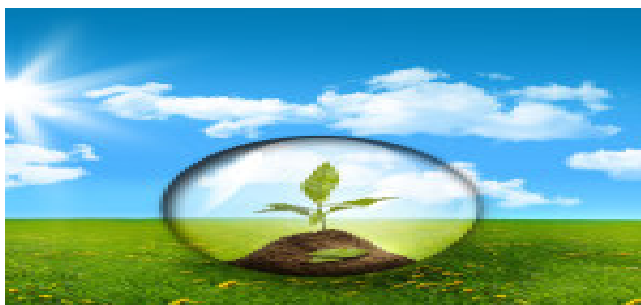


Figure 6: Healthy Ecolife

7. Satisfies equity concerns

- » Benefits of sectoral value-addition primarily accrue to rural households. As the end-product users are mostly from the higher economic groups, the money flows from high end groups to low end groups.
- » Cases of landless families engaged in cocoon production using mulberry contracted from local farmers are common in some states.

Characteristics of Silk Fabrics

Silk is one of the popular fabrics for apparel because of its unique properties. Silk is most luxurious fabric, the most comfortable fabric, the most absorbent of fabrics and the best fabric for colour capable of greatest lustre. These are some factors which makes the fabric more popular. The fabric is cool in summer and warm in winter.

1.5 International Demand of Silk and Constrains in Silk Production Like Labour, Land and Environmental Conditions

No doubt there is increasing demand for quality bivoltine silk in domestic and in international market. India inspite of being the second largest producer of silk in the world has been striving hard to meet the demand of quality silk as more than 90% of its production comprises of ungraded silk. Of the late bivoltine sericulture technologies were stabilized and the country first time could cross 1000MT mark in bivoltine raw silk production recently. Though there has been perceptible improvements in cocoon production and reduction in crop losses due to new sericulture technologies developed by various research institutes in various aspects of sericulture. But, still there is lot more to be done to meet the international demand of silk. Despite, there are various bottleneck problems coming in the way to produce raw silk in bulk to meet the quality as well as quantity silk at the international level.

As far as demand and supply of raw silk, the production of raw silk shows an increasing trend since the last decades. The raw silks produced in different countries are mainly exported to USA. Even in terms of fibre quality silk occupies the highest position. Therefore, as compared to other fibres its value is very high. The demand for raw silk is primarily in USA. On the other hand, considering the supply position of raw silk it is extremely difficult to suddenly increase or decrease the production of cocoon and therefore, it is very difficult to strike a balance between the supply and demand. This ultimately affects the price of cocoons and silk yarn and this is indeed a difficult problem.

Constrains of Sericulture

The sericulture is ideally suited for development of rural economics of the country. It is currently facing several problems which have restricted full utilization of its potential. Some of the major problems are:

1. **Intensity of pests and diseases:** Mulberry and silkworm are prone to certain viral, bacterial and fungal diseases which can drastically reduce production of cocoon and mulberry plant e.g., Grasserie, white root rot etc. There are certain pests too which effect the production of cocoon and mulberry plant like Uzi fly, Green beetles etc.
2. **Shortage of rearing equipment:** The rearing equipments are special kind supremely important in sericulture activity, only a few farmers can afford to produce it.
3. **Inadequate finance for investment:** The capital requirement for cultivating one acre of mulberry and silkworm rearing are high, most of the farmers face problem regarding financial assistance.
4. **Fluctuations in cocoon prices:** There are fluctuations mainly due to a lack of guarantee of cocoon crop, wide variation in the quality of cocoon produced. Absence of standardization and quality control, poor and inadequate marketing facilities and finally import of silk from other countries.
5. **Inadequate market facilities:** Absence of proper marketing facilities creates a major obstacle for the ordinary farmers for orderly and rapid development of agriculture.
6. **Non-availability of layings (dff's):** Sericulturists generally buy layings from the government and licensed seed producers. Sometimes inadequacy, instability and poor quality of the dffs exposes the sericulturists to some real trouble and lead to under utilization of the available mulberry leaf. In such case sericulture becomes less economical.

Constrains in silk production like labour, land and environmental conditions

There was a decreased trend of trained manpower in sericulture in the early stages. Trained manpower plays a vital role in productivity. The main factors for low productivity are geographical variability in different regions of the country, lack of knowledge, skill in adoption of various technologies and poor trained manpower. In order to enhance the qualitative and quantitative production and also to meet the future demands of raw silk production, it was felt to strengthen the human resource development in sericulture in the country. At the foremost, an organization should be aware/understand the changes that take place in and around the world for its survival. The production services should be changed in relevance to socio economic conditions and training needs to be changed sufficiently and meaningfully.

Scope of Sericulture

Owing to favorable climatic conditions, Himalayan states of the country offer tremendous scope for the cultivation of mulberry and development of bi-voltine silk. The bi-voltine Sericulture development has been one of the priority sectors of Indian silk industry for the last few years but its production is yet to meet the target levels. Although India is the second largest producer of silk in the world, yet the production of quality silk is limited. However, the scope of sericulture is very much broad which is evident from the following headings:

1. High employment potential:

- » More than 70 lakh persons are engaged in various sericulture activities in the country.
- » It is estimated that sericulture can generate employment @ 11 man days per Kg of raw silk production (in on- farm and off farm activities) throughout the year. This potential is par-excellence and no other industry generates this kind of employment, especially in rural areas, hence, sericulture is used as a tool for rural reconstruction.

2. Low gestation and high return:

- » Estimated investments of Rs. 12,000 to 15,000 (excluding cost of land and rearing space) is sufficient for undertaking mulberry cultivation and silkworm rearing in one acre of irrigated land.
- » Mulberry takes only six months to grow for commencement of silkworm rearing. Mulberry once planted will go on supporting silkworm rearing year after year for 15-20 years depending on inputs and management provided.
- » Five crops can be taken in one year under tropical conditions.

3. Women Friendly occupation:

- » Women constitute over 60 % of those employed in down-stream activities of sericulture in the country. This is possible because sericulture activities starting from mulberry garden management, leaf harvesting and silkworm rearing is more effectively taken up by the women folk. Even reeling industry including weaving is largely supported by them.

4. Eco-friendly activity:

- » As a perennial crop with good foliage and root-spread, mulberry contributes to soil conservation and provides green cover.
- » Waste from silkworm rearing can be recycled as inputs to garden.
- » Dried mulberry twigs and branches are used as fuel in place of firewood and therefore reduce the pressure on vegetation/forest.
- » Being a labour intensive and agro-based activity, involvement of smoke-emitting machinery is minimal.
- » Development programmes initiated for mulberry plantation are mainly in upland areas where unused cultivable land is made productive.
- » Mulberry can also be cultivated as intercrop with numerous plantations.
- » Mulberry being a deep-rooted perennial plant can be raised in vacant lands, hill slopes and watershed areas.
- » Currently only about 0.1% of the arable land in the country is under mulberry cultivation.

5. Ideal programme for weaker sections of the society:

- » Sericulture can be practiced even with very low land holding.
- » $\frac{3}{4}$ acre of mulberry garden and silkworm rearing can support a family of three without hiring a labour.
- » Features such as low gestation, high returns make sericulture an ideal programme for weaker sections of the society.
- » Vast tracts of forest based tasar food plantations available in the country, if judiciously exploited for rearing tasar silkworms, can offer supplementary gainful employment for tribals.

6. Transfer of money from rich to poor:

- » Silk is produced in developing countries but consumed in development countries.
- » Sericulture being a cottage industry is practiced primarily by rural poor people and the final product, the silk is consumed by rich and affluent class of society.
- » Majority of silk goods are purchased by the urban rich and the middle class and around 57% of the final value of silk fabric flows back to the primary producers in the rural areas.
- » Sericulture is also an eco-friendly sustainable economic activity and helps to check migration of rural youths to the urban areas.

Moriculture, Grainage Technology, Biology Of Mulberry Silkworm And Vanya Sericulture

2.1 Textile Fibres: Their Types; Importance and Advantages of Natural Fibres and Man – Made Fibres; Advantages and Properties of Silk Fibres Over the Other Natural Fibres and Properties of Mulberry Silk in Comparison with Other Types of Silks

Introduction to Textile Fibers

The word textile is derived from the Latin word “texere” which means to weave. Fibers which are used by men for manufacturing clothes for various purposes are known as textile fibers. India is the second largest producer of fiber in the world and mainly produced in India is: cotton.

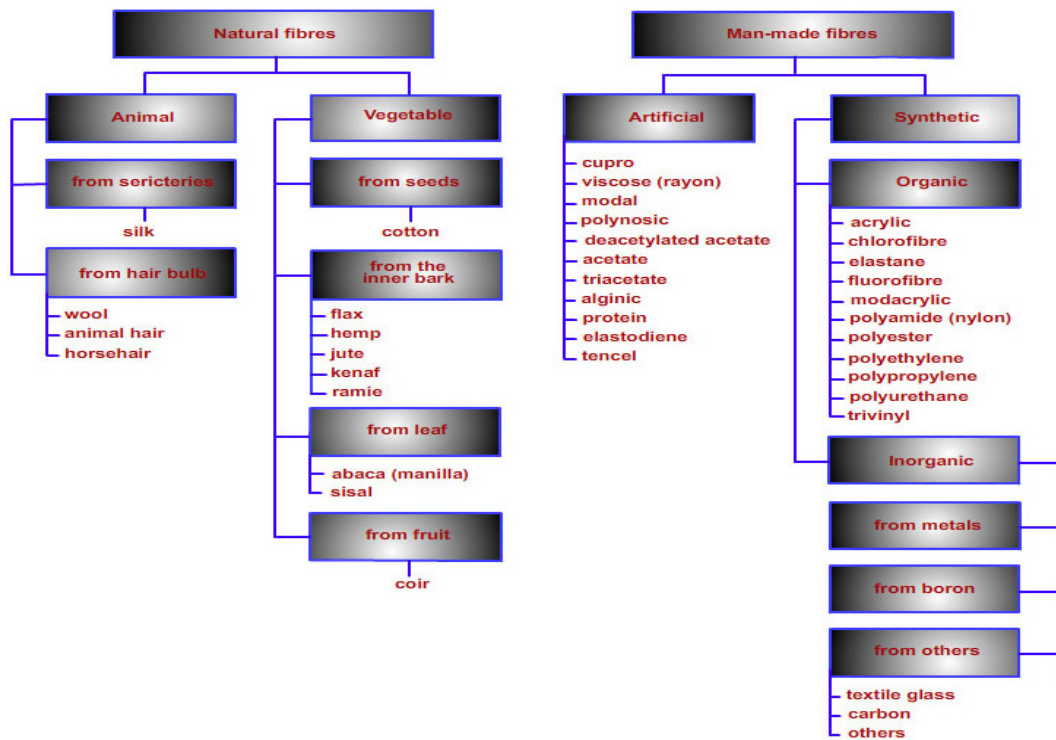
Classification of Fibers

According to the length, fibers are classified as:-

- i. **Staple fibers:** Staple is the name given to fibres of limited length e.g. Cotton.
- ii. **Filament fibers:** Filament is the name of given to fiber of continuous length e.g. silk.

According to the origin of textile fiber, it is classified as:-

» Classification on the Basis of Origin



- i. **Natural fiber:** Natural fiber is defined as substance produced by plant and animals that can be spun into Filament, thread or rope and further be woolen.
- ii. **Manmade fiber:** Manmade fiber is defined as the fiber that is made artificially such as polyester or rayon rather than occurring naturally.

(I) Vegetable Fibers:

1. Cotton

Production: China is the largest producer of cotton in the world. India ranks 2nd position after china. In India Gujarat is the largest cotton producing of 125 lakh bales.

Botanical name: *Gossypium Hirsutum*



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Figure 7: Cotton plants

Common name: Cotton balls

The fruit of a cotton plant is known as cotton balls. Cotton is a soft, fluffy stable fiber that grows in a ball, or protective case, around the seeds of the cotton plants. The fiber is almost pure cellulose fiber presents many notable properties such as flexibility, small thickness, good strength and wear resistance.

2. Jute



Figure 8: Jute plants

Production: India is the largest producer of jute followed by china and Bangladesh. India produces about 61% of total jute production in the world. West Bengal is the largest jute producing state.

Botanical name: *Corchorous olitorius*

Jute is obtained from the stem of jute plant; it is long Soft shiny vegetables fiber that can be spun into coarse and strong threads. Jute fibers are composed primarily of the plant material cellulose and lignin. The jute fibers are white to brown and 1-4 meters long. The fibers are also woven into curtains, Chair covering, Carpets etc.

3. Flax

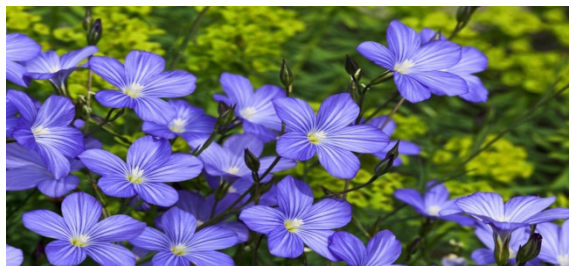


Figure 9: Flax plants

Production: India ranks 3rd in producing flax. Madhya Pradesh is the leading state in producing Flax.

Botanical name: *Linum Ustitatissum*

Flax is also known as common Flax or linseed. It is cultivated in cooler region of the world. Flax fibers are taken from the stem of the plant and are two to three times as strong those of cotton. Flax fibers are naturally smooth, straight, soft flexible. Flax Forbes is also a raw material for the high quality paper industry for the use of printed banknotes and rolling paper for cigarettes and tea bags.

4. Hemp



Figure 10: Hemp plants

Production: China is the largest producer of hemp. India ranks 2nd in production of hemp and Kerala are the leading state in India in the production of hemp.

Botanical name: *Cannabis cativa*

It has been produced for thousands of years as a source of fiber for paper, cloth, building material etc. natural fibers from hump stalk is extremely durable and can be used in the production of textile, clothing, rope, paper and construction materials. There are two principle

types of fiber in hemp-bast or long fibers and hurds or inner short fiber. Traditionally hemp has been grown for its valuable and versatile high quality bast fiber.

(II) Animal Fibres:

1. Wool



Figure 11: Wool

Production: According to International wool textile organization congress in 2014-15 shows that Australia, China and U.S.A are on the top of the world for wool production. In India is the 7th largest producer of wool and it contributes 1.8% of total world about 10% wool produced in India. Rajasthan is the leading state in the production of wool and produced of wool and produces 44% of total production in India. Wool is an animal fiber forms the protective covering of sheep or other hairy animals such as goat, sheep, and rabbits. Wool is the fiber derived from the specialized skin cells, called follicles. Wool fiber is chiefly composed of the animal's protein "Keratin" Wool having diameter ranging from about 1.5 to 3 inch long extremely coarse fiber may be as much as 14 inch long. Color of wool is usually whitish, may be brown or black wool fiber has well to excellent affinity for dyes. Wool has naturally high ultraviolet protection. Wool's natural structure allows it to absorb and release water vapors in to the atmosphere. Keeping you warm in winter and cool in summer, it is non-allergic, durable and longer than cotton fiber.

2. Silk



Figure 12: Silk

Production: China is the leading producers of silk in the world. India is second largest country silk producer in the world. Karnataka is the largest producer of raw silk in India. Silk is called as “Queen of textile”. Silk is obtained from insect *Bombyx mori* L. (mulberry silk worm). Silk is a natural protein fibers composed of proteins fibrion and sericin. Some non-mulberry silkworms also produce silk namely Tasar, Eri and Muga silk. Silk is strong regular, flexible, soft, long filament and have attractive luster. Silk is used in clothing, crafting in making shawls and other valuable products.

(III) Mineral Fibres

1. Asbestos

Production: Russia is the largest producer of asbestos in the world. India ranks fifth position in the producing of asbestos. Andhra Pradesh is the largest producer of asbestos in India. Asbestos is the set of six naturally occurring silicate minerals. Asbestos fibers are strong, heat and chemical. Resident and don't evaporate into the air or dissolve in water. Such properties make it ideal for use in boils pipes, use in ceiling and floor tiles etc. It is banned in UK since 1985 and this ban was due to its bad effect on health of humans. It is prove to be carcinogenic.



Figure 13: Asbestos

(IV) Man-Made Fibers

(I) Regenerated or Artifical Fibers

Artificially fibers are obtained by processing natural raw material and it is artificially or regenerated fibers.

1. Viscose

Viscose fiber is made from cellulose from wood pulp, by treating the cellulose compound with sodium hydroxide and carbon disulphide. The viscose solution formed is used to spin the fiber used in dress, linings, shirts, coats, jackets and other wear. It is also used in the industrial yarns and carpets.

Viscose rayon

Figure 14: Viscose

2. Acetate

Acetate fiber is one of earliest synthetic fiber and is base on cotton or tree pulp cellulose. It was invented by two Swiss brothers' camelli and Henri Dreyfrud in Switzerland. Acetate is very valuable manufactured fiber that is low in cost and has good draping qualities.

(II) Synthetic Fibers

Synthetic fibers are man-made fibers that come from chemical resource.

1. Polyester

Polyester is synthetic polymer made of purified "terephthalic acid" for its dimethyl ester (Dimethyl terephthalate and monoethylene glycol). Fabric woven or knitted from polyester thread or yarn are used extensively in apparel and home furnishing, shirts, pants, jackets, hats, bed sheets, blankets etc. Polyester is also use to make bottles, films, canoes, filters and Film isulation for wire. Polyester is widely used as finish on high quality wood products such as guitars, pianos and vehicle.

2. Nylon

Nylon is one of the most commonly used polymers, first used commercially in a nylon bristle toothbrush (1938). Nylon is made of frequently referred to as polyamide. Nylon fibers are used in many applications, including clothes, fabric package papers, carpets, musical strings, pipes, rope etc. Nylon is condensation polymer formed by reacting equal part of ademine and dicarboxylic of each monomer. Nylon is highly resistant to insects, fungi, animals and many chemical used in carpets.

Importance of Natural Fibers

- i. Natural fibers are healthy choice: most people known natural fibers provide natural ventilation. Wool garments acts as insulators against both cold and heat coconut fibers used is mattresses have natural resistance to fungus and mites hemp fibers has anti bacterial properties and studies have shown mat lines is most hygiene textile for hospital bed sheets.
- ii. Natural fibers are high-tech choice: Natural fibers have good mechanical strength, low weight and low cost.

- iii. Friendly processing, no wear of tooling, no skin irritation.
- iv. According to United Nations natural fibers provide a multitude of human and environmental health as well as economic benefits. Each fiber has its own purpose in manufacturing, and provides better quality and more sustainable textile than synthetic materials.

Importance of Man-Made Fibers

- i. Manmade fibers are durable. Manmade fibers are made by following a technical process and that is why this kind of textile fiber is comparatively durable.
- ii. Dimensionally stable: Natural fibers are not stable like manmade fibers. So, commercially the demand of man-made fibers is huge.
- iii. Strength: this fiber is more stable strength than natural fibers.
- iv. Low cost: As the entire chemical and raw material is available all time in any season; the ultimate cost of manmade fiber is less.
- v. Better elongation properties.
- vi. The raw material that is used to produce man-made fiber is specified.

Advantages of Silk Fibers

Among all natural fibers like cotton, wool, asbestos etc. the silk is called as “the Queen of textile.”

- » Silk is the only fiber that has to spin before it is woven as.
- » Silk is the strongest natural fiber known.
- » It is a natural temperature regulator, helping the body retain heat in cold weather and expel heat in warm conditions.
- » Silk is hypoallergenic; it does not attract dust mites and is a natural fungal repellent.
- » Silk is wrinkle and tear resistant, and dries quickly.

Table 12: Comparison of silk with other natural fibres

S. No.	Properties	Silk	Other natural fiber
1.	Elasticity	More elastic	Show less elasticity than silk
2.	Luster	More luster	Less lustrous
3.	Affinities towards dyes	Show strong affinities towards dyes	Show less affinities as compare to silk
4.	Strength	It is strong as compared to other natural fabrics	Show less strength but wool show little bit more strength as compare to other natural fibers but less than silk
5.	Resistance	Wrinkle and tear resistance and dries quickly	Show less resistance towards wrinkle, tear and dries not quickly

Properties of Silk: Properties of Silk in Comparison With Others Fibers; Wool, Cotton and Jute. Properties of Mulberry Silk in Comparison With Other Types of Silks; Tasar, Eri and Muga

Silk the “Queen of Textile”, unchallenged so far by other fibres, is a nature’s gift for mankind. Silk with its fineness, evenness, durability and luster had fascinated the women for all over the world. Today, a number of varieties of silk fabrics are produced on handlooms and sophisticated power looms. This requires different qualities of raw silk. In order to assist the weaving the industry in the selection of the required raw silk, it must be first tested and classified.

The testing of raw silk is based on the procedure laid by the International Silk Association (ISA). This procedure is quite conservative and the equipment used is consistent with traditional patterns when compared to procedures followed for general textile products.

The traditional method has been widely preferred in silk producing and consuming countries of the world. The mechanical testing procedure is similar everywhere, but the compilation of test results and standards for various grades differs slightly from country to country.

Physical Properties of Silk

- 1. X – Ray of silk:** X-ray photographs show definite X-ray spots, which indicate that fibroin is crystalline in structure.
- 2. Hygroscopic nature:** Silk is very hygroscopic and is capable of absorbing up to 30% of its

weight of moisture, when exposed to saturated conditions of atmosphere without feeling wet or dry. But when oven dry silk is kept for a specified time in a standard atmosphere having 65% humidity at 25°C, the silk absorbs only 11% of its weight if the silk is raw and 10% if it is in degummed condition.

3. **Tensile strength:** Silk has enormous tensile strength with a breaking load nearly 5000 kg/cm² or as much as 4 g/denier. It has an elongation of about 20% of its original length before breaking.
4. **Density of silk:** Raw silk has a density of 1.33 whereas degummed silk has 1.25.
5. **Degumming loss:** Sericin which is the soluble portion of the bave forms between 22 to 30% of the whole weight.
6. **Scroop:** Scroop refers to the crackling sound emitted when the fibre is squeezed or pressed. The well known “rustle” of silk fabrics is due to the property of scroop.
7. **Electrical conductivity:** Silk is a poor conductor of electricity and accumulates a static charge by friction which at times renders it difficult to handle in the manufacturing process.
8. **Effect of light:** Silk is sensitive to weakening by UV light. It loses as much as 50% of its strength after 6 h exposure to UV light. Scored silk requires a much shorter time for tendering. Silk in the form of fabric is readily damaged by sunlight.
9. **Effect of heat:** If white silk is heated in an oven at 110.5°C for 15 minutes it begins to turn yellow. Above 170°C, silk disintegrates and on burning it gives an empyreumatic odor.
10. **Action of water:** Water does not permanently affect silk fibre. Its strength decreases about 20% when wet but regains the original strength upon drying. The fibre swells, but does not dissolve when immersed in warm water.
11. **Organic acids:** Silk is not affected by cold organic acids like acetic acid, formic acid, citric acid and tartaric acid when these are used in processing of silk. Acetic acid is used in the silk industry to increase the luster of the silk by dissolving the lipids of sericin. The organic acids in hot conditions affect the silk quality.
12. **Inorganic acids:** Some of the inorganic acids like sulphuric, hydrochloric and nitric acids dissolve the sericin and fibroin proteins. In cold and dilute conditions they are less effective. Silk becomes gelatin substance and releases ammonia gas with nitric acid. When silk is treated with dilute HNO³ at high temperature, it acquires/turns to yellow colour which is called Nitro silk. The nitro silk is used in harmonium.
13. **Action of alkalies:** Silk is not sensitive to dilute alkalies, but strong hydroxides or alkalies like; NaOH, CaOH, KOH etc. in high concentrations readily dissolves the silk. Fibrilous

nature is caused when the silk fibroin is treated with 2% KOH and this is called lousiness.

- 14. Action of metallic salts:** Silk has great affinity for metallic salts like; Zinc Sulphate, Tin Sulphate and Ferrous Sulphate. Silk absorbs about 30% of metallic salts which increases its weight and this process is called loading of silk.
- 15. Action of oxidizing agents:** Some of the oxidizing agents on silk like KMnO_4 , SO_2 and H_2O_2 in low concentration at high temperature bleach the silk and replace the colour pigments.
- 16. Affinity to dyes:** Silk has a greater affinity for dye than any other textile fibre. Silk absorbs dyes at a low temperature and being a protein; it possesses both acid and basic properties and therefore can be dyed with basic or acid dyes.

Table 13: Difference between Physical properties of Cotton and Wool

S. No.	Properties	Cotton	Wool
1.	Fibre	It is cellulose fibre	It is a protein fibre
2.	Color	Cotton is white, creamy white, yellowish white etc	Wool is white, white brown and black
3.	Tensile strength	Cotton is moderately strong fibre. It has tenacity of 3.5 g/denier	The tensile strength of wool is 1.7g/denier
4.	Specific gravity	1.5-1.60	1.30-1.40
5.	Moisture regain	8.5%	16-18%
6.	Lusture	Little lusture	Little lusture in nature

Table 14: Difference between Chemical properties of Cotton and Wool

S. No.	Properties	Cotton	Wool
1.	Effect of heat	Cotton has an excellent resistance to degradation by heat. It begins to turn yellow after several hours of 120 degree Celsius.	Heat effect the wool fibre greatly wool becomes heat at 130 degree Celsius it decomposes.
2.	Effect of alkalis	Cotton has an excellent resistance to alkalis. It swells in causative alkalis (NAOH) but it does not damage.	Wool is particularly sensitive to alkaline substances. Strong alkaline effect on wool fiber.

Table 15: Different Properties of Silk, Cotton, Wool and Jute

Properties	Silk	Cotton	Wool	Jute
Elasticity	More elastic	It is inelastic and rigid fiber.	It is not so inelastic fiber.	It has no elasticity.
Lusture	More lustrous	Very little lustre.	It has also very little lustre.	No lustre.
Strength	It is strong as compared to other fibers.	It is moderately strong fiber.	It shows little bit more strength as compared to cotton.	3-4 gm / denier
Specific gravity	1.25-1.34	1.52-1.60	1.30-1.40	

Properties of Non - Mulberry Silk

1. Properties of tasar silk

Tasar silk comes from the silkworm, (*Antheraea mylitta*). It is polyphagous and feed on a number of food plants. Its principal host plants are Asan (*Terminalia tomentosa*) and Arjun (*Terminalia arjuna*). Tasar cocoons are of light brown to brown colour. Density of tasar silk is about 1.34. Tensile strength of tasar silk is 2.5 -3.0 gm/ denier. Tasar silk is most important among the non mulberry silks accounting for about 90% of it.

2. Properties of muga silk

Muga silk comes from the silkworm, (*Antheraea assemensis*) it is polyphagous which feed on the leaves of several plants. Muga silk is a golden yellow lustrous silk. Muga silk is the 'GOLD OF ASSAM' and it is the rarest silk is in the world available only in Assam and nowhere else in the world. It is moisture regain capacity is about 30% which is better than other silks.

3. Properties of eri silk

Eri silk comes from the silkworm (*Philosamia ricini*) being polyphagous feeds on several variety of food plants. Castor leaf is the main food of the eri worms. Eri silk is darker and heavier than the other silks. Due to its thermal property it is warm in winter and cool in summer. Due to which it is suitable fabric for shawls, jackets, blankets and dress material etc. It has high moisture regain property. Specific gravity of Eri silk is 1.306. It is highly hygroscopic and absorbs moisture equal to its weight.

Table 16: Comparison between Mulberry and Non-Mulberry Silk

Properties	Mulberry	Tasar	Muga	Eri
Food plant	Monophagous	Polyphagous	Polyphagous	Polyphagous
Colour	White in colour	Light brown to brown colour	Golden colour	White or brick red colour
Lusture	More lustrous	No lusture	Golden lusture	No lusture
Reelability	Reelable	Reelable	Reelable	Non-reelable

2.2 Mulberry Cultivation: Raising of Mulberry Plantation, Soil for Mulberry Cultivation; System of Mulberry Cultivation in Different Agro Climatic Conditions. Cultivated Varieties of Mulberry in Different Parts of India

Raising of Mulberry Plantation

1. **General description:** Mulberry is a fast growing deciduous woody perennial plant. It has a deep-root system. The leaves are simple, alternate, stipulate, petiolate, entire or lobed. Number of lobes varies from 1 to 5. Plants are generally dioecious. Inflorescence is catkin with pendent or drooping peduncle bearing unisexual flowers. Inflorescence is always auxiliary. Male catkins are usually longer than the female catkins. Male flowers are loosely arranged and after shedding the pollen, the inflorescence dries and falls off. Number of parianth lobes are 4. Numbers of stamens are 4 and implexed in bud. Female inflorescence is usually short and the flowers are very compactly arranged. Numbers of parianth lobes are 4 and persistent. Ovary is one-celled and stigma is bifid. The chief pollinating agent in mulberry is wind. Fruit is a sorosis and the colour of the fruit is mainly violet black.

Most of the species of the genus *Morus* and cultivated varieties are diploid having 28 chromosomes. However, triploids ($2n=(3x)=42$) are also extensively cultivated for their adaptability, vigorous growth and quality of leaves.

2. **Climatic requirement of mulberry:** Mulberry thrives under various climatic conditions ranging from temperate to tropic located north of equator between 28° N to 55°N latitude. The ideal range of temperature is from 24-28°C. It grows well in places with annual rainfall ranging from 600mm to 2500mm. In area with low rainfall, the growth is limited due to moisture stress resulting in low yields. On an average mulberry requires

85,000 gallons of water per hectare once every 10 days in case of loamy soils and 15 days in clayey soils. The atmospheric humidity in the range of 65–80% is ideally suited for mulberry growth. Sunshine is one of the important factors controlling growth and leaf quality. In tropics, mulberry grows with a sunshine range of 9.0 to 13.00 hours a day. Mulberry can be cultivated from sea level up to an elevation of 1000 m above mean sea level.

3. **Soil for mulberry cultivation:** Mulberry flourishes well in soils which are flat, deep, fertile, well drained, loamy to clayey, porous with good moisture holding capacity. The ideal range of soil pH is 6.2 to 6.8. The optimum pH required for mulberry is 6.5 to 6.8. Soil amendments may be used to correct the soil to get required pH. The quantities of gypsum or lime to be applied in different cases are as mentioned below:

Table 17: Soil Amendment: (To be taken up after soil test)

S.No.	pH range quantity of lime/ha (to bring pH to 6.8)	Quantity of gypsum/ha
1.	7.4 to 7.8	2.0 M/T
2.	7.9 to 8.4	5.0 M/T
3.	8.5 to 9.0	9.0 M/T
4.	9.1 to above	14.0 M/T

Table 18: pH range quantity of lime/ha (to bring pH to 6.8)

pH range	Plain	Hilly areas	Soil type
5.5 to 6.5	1.25 M/T	2.5 M/T	Sandy
	2.50 M/T	5.0 M/T	Sandy loamy
	5.0 M/T	7.5 M/T	Loamy
	7.5 M/T	8.75 M/T	Clay loamy

4. Methods of application:

The powdered gypsum/lime is mixed well with soil with soil of the garden and irrigated to stagnation for 48–72h. Later the water is leached out by drainage and dried (suitable for ploughing and intercultural operations).

Systems of Mulberry Cultivation in Different Agro-Climatic Conditions

A) Mulberry Cultivation in South India under Rainfed Conditions (Karnataka, Andhra Pradesh and Tamil Nadu)

I. Suitable Mulberry Varieties

Kanva-2, S-13 and S-34 varieties are recommended for rainfed (rainfall : 500-800 mm) regions of South India.

Kanva-2:

Belongs to *Morus indica* - Diploid. Widely cultivated in Southern India. Selection from natural population of Mysore Local variety.

Flower and sorosis:

Female; profuse flowering, many sorosis.

Economic characters:

- » Medium leaf maturity; yields about 30 to 35 MT/ha/year under irrigated condition. Leaf moisture content 70%, protein content 21% and sugar content 11.5%.
- » High rooting ability (80%) and wide adaptability.
- » Resistant to leaf spot.
- » Moderately resistant to leaf rust and powdery mildew.

S-13:

Belongs to *M. indica*. Selection from open pollinated hybrids of Kanva-2. Recommended for rainfed areas of South India during 1990.

Flower:

Male; profuse flowering.

Economic characters:

- » Yields 8-12 MT/ha/yr under rainfed conditions depending on rainfall.
- » Moisture content 70.6% protein content 24.3% and sugar content 13.8%.

- » Resistant to leaf spot and powdery mildew, moderately resistant to leaf rust and tukra infestation.

S-34:

- » Belongs to *M. indica* - Diploid.
- » Selection from progeny of S30 x Berc 776.
- » Recommended during 1990 for rainfed areas with black cotton soils of South India.

Flower and sorosis:

Male; profuse flowering, occasionally few sorosis.

Economic characters:

- » Under rainfed conditions, yields about 15 MT/ha/yr.
- » Moisture content 70%, crude protein content 23.7%. Soluble sugar content 13.2%.
- » Resistant to powdery mildew and leaf rust.
- » Moderately resistant to leaf spot and susceptible to tukra infestation.

II. Establishment of Mulberry

- Preparation of land:** The land meant for mulberry cultivation is ploughed deep with heavy mould board plough up to a depth of 30-35 cm. Thereafter the land is repeatedly ploughed 23 times with a country plough to bring the soil to a fine tilth. The land should be properly leveled if it is sloppy. A basal dose of well decomposed Farm Yard Manure or compost is applied at the rate of 10 MT/ha and thoroughly incorporated into the soil.
- Spacing:** The spacing commonly followed for a rainfed garden is 90 x 90cm Pits of 35 x 35cm. are prepared. About 1 kg farm yard manure/pit should be added.
- Preparation of cutting and planting:** Branches of 8-10 months old and about 50 mm. in diameter should be used for preparation of cuttings of 22-25 cm. length with 5-6 healthy buds. Three cuttings are planted/pit in a triangular form with spacing of 15 cm. leaving only one bud exposed above soil surface. If planting is done with saplings, then one sapling is sufficient/pit. Planting should be done during June /July after onset of monsoon.
- Inter cultivation:** During first year of plantation, inter cultivation should be done manually. Once the mulberry plants are established, bullock ploughing is carried out.

Application of fertilizer: 50 N : 25 P : 25 K Kg/ha/yr in two doses.

First dose

Suphala (15:15:15) 167kg, after 2 months of planting.

Second dose

Urea 55 kg or CAn (100kg) or Ammonium sulfate (125kg), end of September or early October before cessation of monsoon rains.

- iv. **Pruning and leaf harvest:** First crop should be taken 6 months after plantation when mulberry gets well established. Then onwards, two more crops are taken during first year by leaf picking method. Mulberry should be pruned after the completion of one year at the onset of next monsoon. The pruning is carried out with a sharp sickle or a pruning saw at the height of 25-30 cm. from the ground.
- v. **Green manuring and cover mulching:** Green manure crops can be grown as inter-crop with mulberry. It should be done during monsoon only. The green manure crops (cow pea, horse gram, dhaincha) should be incorporated into soil by ploughing before the flowering starts and well before rains cease. After that the plots may be given cover mulching with any dry material or weeds in which seed is not a source of multiplication.

III. Maintenance of Mulberry

- » Under rainfed Condition (Second year onwards).
- » Inputs required for rainfed garden (per ha. per year).
- » Recommended inputs for gardens maintained under rainfed condition.
- i. **Spacing :**
 - » 90 cm. x 90 cm.
 - » FYM/compost, 10 MT, single dose at the onset of monsoon.
 - » Azotobacter biofertilizer, 4 kg/crop, two times/yr (during rainy season).
 - » VAM inoculum, 1000 kg, once in life span of mulberry (inoculation through maize rootlets).
 - » Suphala, 167 kg, I crop.
 - » Single Super Phosphate, 156 kg, I crop.

- » Muriate of potash, 42 kg, I crop.
- » Urea (55 kg) or Cam (100kg), III crop.
- » Green manuring, 15 kg

Crops like horse gram, cow pea, sun hemp, dhaincha, etc., should be incorporated into soil by ploughing before flowering and cessation of monsoon.

IV. Leaf Harvest

Individual leaf harvesting should be made. The yield for different varieties is as mentioned below:

K-2 – 10-12 MT/ha/yr S-13 – 14-15 MT/ha/yr S-34 – 14-15 MT/ha/yr.

B) Mulberry Cultivation in South India under Irrigated Condition

I. Suitable Mulberry Varieties

Kanva-2, S-36, S-54, DD, MR2 (especially in Tamil Nadu) and V-1 varieties are recommended for irrigated conditions.

Kanva-2:

Belongs to *Morus indica* - Diploid.

- » Widely cultivated in Southern India after the same was recommended for cultivation in 1969 by CSR & TI, Mysore. Selection from natural population of Mysore Local variety.

Flower and sorosis:

Female; profuse flowering, many sorosis.

Economic characters:

- » Medium leaf maturity yields about 30 to 35 MT/ha/year under irrigated condition.
- » Leaf moisture content 70%, protein content 21% and sugar content 11.5%.
- » Resistant to leaf spot.
- » Moderately resistant to leaf rust and powdery mildew. High rooting ability (80%) and wide adaptability.

S-36:

Belongs to *M. indica*. Developed at CSRTI, Mysore and recommended during 1984. Evolved from Berhampore local by chemical mutagenesis. Cultivated in Southern India. Moderate rooting ability.

Economic characters:

- » Yields about 38 - 45 MT/ha/yr under assured irrigated conditions of South India.
- » Moisture content 76 % protein content 22 % and carbohydrate content 28 %.
- » Tolerant to leaf spot and powdery mildew.
- » Moderately susceptible to leaf rust and to tukra infestation.
- » Most suitable to young age silkworm rearing.
- » Sapling plantation recommended due to moderate rooting ability.

S-54:

- » Belongs to *M. indica*. Developed at CSRTI, Mysore and recommended during 1984.
- » Selected from Berhampore local by chemical mutagenesis (EMS).
- » Recommended for assured irrigated conditions of South India.

Economic characters:

- » Yields about 45 MT/ha/yr under assured irrigated conditions. Highly responsive to agronomical input.
- » Moisture content of leaf 70.5% protein content 23.9% and sugar content 13.8%.
- » Moderately resistant to powdery mildew and leaf rust and resistant to leaf spot. Loses moisture very quickly.
- » Good rooting ability.

DD:

- » Selected from natural population of Dehra Dun variety and recommended by Karnataka State Sericultural Research and Development Institute, Thalaghattapura. Recommended for Southern India.

Morphology:

- » Erect, thin branches, coarse leaves, greenish grey colour bark. Lower branches spreading, leaves unlobed, big size, ovate shape.
- » Yields 35-40 MT/ha/yr under assured irrigation condition.

MR – 2:

- » Belongs to *M. sinensis* – Diploid. Selection from open pollinated hybrid population. Developed at CSR & TI, Mysore and recommended for propagation in Tamil Nadu.
- » Mainly cultivated in Tamil Nadu under both irrigated condition in plains and rainfed conditions in hilly regions.

Economic characters:

- » Yields about 30-35 MT/ha/yr under irrigated conditions of Tamil Nadu.
- » Moisture content 68%, protein content 23.2%, sugar content 13.2%.
- » Resistant to powdery mildew disease, suitable for hilly areas.

V-1:

- » Belongs to *M. indica* L. Recently developed from a cross of S-30 and Berc.776 at CSR&TI, Mysore.
- » Recommended during 1996 for assured irrigated conditions.

Flower:

Male, profuse flowering, occasionally few sorosis.

Economic characters:

- » Yields about 70 MT/ha/yr under assured irrigated conditions. Very high sprouting.
- » Moisture content 78.9% and 72.5% in young and matured leaves respectively, protein content 24.6% and total sugar content 16.98%.
- » Moderately resistant to leaf rust and tukra infestation and resistant to leaf spot. Quick sprouting ability and very high rooting ability (> 94%) high photosynthetic rate and higher water use efficiency are additional advantages. Moreover, leaves are suitable for both young and grown bi-voltine silkworm rearing.

II. Establishment of Mulberry

- i. **Selection of site:** Mulberry flourishes well in soils which are flat, deep, fertile, well drained, loamy to clayey, porous with good moisture holding capacity. The ideal range of soil pH is 6.2 to 6.8. Mulberry can be grown in saline, alkaline and acidic soils after suitably amending the soils.
- ii. **Preparation of land:** The land meant for mulberry cultivation is ploughed deep with heavy mould board plough up to a depth of 30 – 35 cm. Thereafter the land is repeatedly ploughed 2-3 times with a country plough to bring the soil to a fine tilth. The land should be properly leveled if it is sloppy. A basal dose of well decomposed farm yard manure or compost is applied at the rate of 20 MT/ha and thoroughly incorporated into the soil.

Plantation can be raised by using either cuttings or saplings. The varieties ideally suited for irrigated conditions are Kanva-2, S-36 and V-1. Branches of 6-9 months old, in diameter should be used for preparation of cuttings of 15-18 cm. length having 3-4 healthy buds for raising nursery or for planting directly in the field.

- iii. **Spacing:** Plant spacing of 90 x 90 cm. is ideal for mulberry. While taking Plantation directly, two cuttings / pit required to be used. In case of using saplings, only one sapling/ pit is sufficient. Presently a paired row plantation with the spacing of (90+150) cm x 60 cm, is recommended.
- iv. **Inter-cultivation:** Two months after planting, weeding is done. A second weeding is done after another 2-3 months. Thereafter, inter-cultivation should be done after every shoot or leaf harvest.
- v. **Irrigation:** The plantation should be taken up during the onset of monsoon to take advantage of the rains. If the rain is not sufficient, the land should be irrigated at regular intervals of 8-14 days depending on type of soil. About one and a half to two acre inches of water is required/irrigation.
- vi. **Application of fertilizer:** The total dose of fertilizer to be applied in first year is 100 N: 50 P: 50 K/kg/ha/yr. This is applied in two doses. The first dose is applied when the plantation is about 2 months old at the rate of 50 N: 50 P: 50 K/kg/ha. The second dose is applied after taking the leaf harvest at the rate of 50 kg N alone/ha.
- vii. **Pruning:** After 6 months of plantation, mulberry attains a height of about 1.50 to 1.75 m. and is ready for harvest. The first harvest is taken by bottom pruning. The second leaf harvest is taken after 12 weeks of first leaf harvest and the third harvest is taken 12 weeks after the second harvest by shoot harvest. From second year onwards, harvest is made at an interval of 70 days by shoot harvest method.

III. Maintenance of Mulberry under Irrigated Conditions (Second Year Onwards)

Spacing 90 cm x 90 cm or (90 + 150) cm x 60 cm

Recommended inputs:

Table 19: Recommended Inputs under Irrigated Conditions (Second Year Onwards)

FYM/compost	20 MT	In two equal doses split doses (10 MT FYM+ MT vermicompost)
Azotobacter	20 Kg	In five equal splits
N-triacontanol***	250 ml	In two equal split doses/crop
VAM inoculum ** (for existing garden)	1000 kg	One dose in the life span of mulberry (inoculation through maize as host plant)
Ammonium sulphate* or Urea or CAN	750 kg 325 kg 600 kg	In five equal split doses
Single Super Phosphate	375 kgs	In two equal split doses (I and III crop)
Muriate of Potash	200 kg	In two equal split doses (I and III crop)

*50% of chemical fertilizer can be cut down due to the application of azotobacter and VAM

** VAM inoculation is not required for the garden, planted with Mycorrhiza inoculated saplings

*** 1st spray: In between 10-15 days after pruning/leaf plucking 2nd spray: 10 days after 1st spray

IV. Leaf Harvest

Leaf harvesting is done either through individual leaf harvest or shoot harvesting. Later one is more economical and useful for shoot method of silkworm rearing. The yield of varieties is mentioned below:

Kanva-2 - 32-35 MT/ha S-36 - 38-45 MT/ha V-1 - 60-70 MT/ha

C. Mulberry Cultivation in Hilly Areas

I. Suitable Mulberry Varieties

S-1, S-7999, S-1635, S-146, Tr-10 and BC-259 varieties are recommended for hilly regions of north and north-eastern India.

II. Establishment of Mulberry

- i. **Preparation of land:** If the land is having gentle slope, it can be leveled with minor land shaping and providing suitable type of bunds across the slope. If the slope is more, contour bunding terrace planting or contour line planting can be adopted. In more sloppy areas, platform for individual plants on contour lines is more suitable as the same involves less soil cutting.
- ii. **Spacing:** Spacing for tree planting depends on soil topography, extent of land available for cultivation and training method. In case of gentle slope, 3' X 3', 5' x 5' may be adopted. In case of more sloppy land 10' x 10' can be adopted. Pits are to be prepared for plantation. In case of deep textured loose soils, 45 x 45cm. and in had shallow soils 60cm x 60cm x 60cm) pits are to be prepared. For each pit, 5kg (one iron pan) of FYM or compost must be applied.
- iii. **Planting:** Saplings of 5 months age with 5-6 feet are found suitable to plant during the regular onset of monsoon. One sapling/ pit should be planted. The saplings should be supported with stick to ensure straight growth.
- iv. **After care of plantation:** After one month, all the buds except top 5-6 should be removed carefully without damaging the bark. Weeds around the plant should be removed and regular pot watering should be given. After 3 months of planting, second weeding should be given and 25g of suphala/plant should be applied in trench and should be covered with soil. 2nd dose of fertilizer (25g urea/plant) should be given before cessation of monsoon. Plants must be protected from grazing.

III. Recommendation with Institute Technologies for Hilly Areas (Tropical high land)

Spacing 90 cm. x 90 cm.

Table 20: Recommended Inputs under Hilly Areas (Tropical high land)

FYM/compost	20 MT	In single dose in the month of Jan/Feb.
Azotobacter	7.5 kg	In 3 equal splits doses.
VAM inoculum	1000 kgs	In single dose in the life span of mulberry
CAN	200 kg	In 3 equal split doses
SSP	156 kg	In 2 equal split doses
MOP	84 kg	In 2 equal split doses

CAN: Calcium Ammonium Nitrate

SSP: Single Super Phosphate

MOP: Muriate of Potash

Since the recommendation is general, the inputs like fertilizers and amendments may be applied on the basis of soil test reports.

D. Inputs for Mulberry Cultivation in Temperate and Sub-Temperate Regions

The following varieties are found suitable for temperate and sub-temperate regions.

Table 21: Recommended Mulberry varieties under temperate and sub-temperate regions

Temperate	Goshoerami, China white
Sub-temperate	Chak majra, 5-146
i. Temperate (Kashmir)	FYM 20 tons/hr/yr irrigated After annual pruning July-August

All types of plantation (bush, dwarf tree) maintained under irrigated condition.

- ii. Temperate (Kashmir) - 1st dose in April-May
NPK @ 300:150:150 ha/yr – 2nd dose in June-July in two equal splits

The leaf yield of different varieties are as mentioned below:

Goshoerami	15-20 MT/ha/yr
China white	15-20 NIT/ha/yr
Chak majra	20-22 NIT/ha/yr

» Mixed Farming:

Mulberry can be successfully grown as an inter-crop (medium mixed tree) between the rows of tea/coffee as shade plants. By this besides providing shade to the tea/coffee plants, good quantity of quality leaves can be obtained for silkworm rearing and as feed for cattle and goats. Further, the pruned shoots are a good source of firewood.

Mulberry can also be grown as an inter-crop for cultivation in the wider space existing between sources of coconut plantation. A survey has shown that mulberry is inter-cropped with coconut in Channapatna, Ramanagaram, Kanakapura and Bangalore areas of Karnataka state.

Cultivated Species and Varieties of Mulberry in Different Parts of India

There are about 68 species of the genus *Morus*, the majority of them occur in Asia, especially in China (24 species) and Japan (19). Continental America is also rich in its *Morus* species. The genus is poorly represented in Africa, Europe and Middle East, and it is not present

in Australia. In India, there are many species of *Morus*, of which *Morus alba*, *M. indica*, *M. serrata* and *M. laevigata* grow wild in the Himalayas. Several varieties have been introduced belonging to *M. multicaulis*, *M. nigra*, *M. sinensis* and *M. phillippinensis*. Most of the Indian varieties of mulberry belong to *M. indica*.

In China there are 15 species. Out of which, 4 species, *Morus alba*, *M. multicaulis*, *M. atropurpurea* and *M. mizuho* are cultivated for sericulture. In the ex-USSR *Morus multicaulis*, *M. alba*, *M. tartarica* and *M. nigra* are present.

Though mulberry cultivation is practiced in various climates, the major area is in tropical zone covering Karnataka, Andhra Pradesh and Tamil Nadu states, with about 90%. In the subtropical zone, West Bengal, Himachal Pradesh and north-eastern states have major areas under mulberry cultivation.

Popular mulberry cultivars

There are large number of newly evolved and their parental varieties of mulberry are available in germplasm banks. The popular varieties which are cultivated in different parts of India are:

Kanva-2, Dhar local, Berhampore local, Kotia, Mysore local, Botatul, Sujan pura-1, C763, S1, Sujan pura-2, S146, MR-2, Sujan pur-3, S799, Assam bola, S-13, Sujan pur-4, Jatinuni, S-36, Sujan pur-5, S-54 & Kutahi.

1. **Kanva-2 (M5) and Mysore local:** These are the two most important varieties. Mysore local grows in rain fed conditions and is drought resistant, can with stand dry climatic fluctuations. M5 is superior variety. It gives lusture leaf yield. The leaves are better quality with more protein content under irrigated conditions, the leaf yield per hectare is 30 -35 MT.

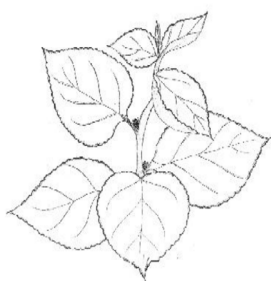


Figure 15: M5.



Figure 16: Mysore Local

2. **S-30:** It grows in all types of soils. The leaves are bigger in size and more proteinaceous. The leaf yield per hectare / year is 35- 38 MT.
3. **S-36:** Leaves are large, heart shaped, thick, high quality more succulent and rich in protein and fiber content. The leaf yield per ha / year is 35-45 MT.

4. **S-54:** It can be consider as best of the 'S' – series. It is suitable for irrigated conditions. It has large leaves, smoothly waxy surface. It has shorter intermodal distance. It has quick sprouting potentiality. The leaf yield under different climatic conditions is superior, leaf yield per hect./ year is 37-47 MT.
5. **S-13:** It is drought resistant. The plant grows quickly. Leaves are thick, proteinaceous. During summer or drought conditions it supplies quality leaf for rearing the silk worms under irrigated conditions the leaf yield per hect/year is 30-35 MTs and in drought conditions 15-18 MT.
6. **V₁:** This is the new variety evolved by CSR and TI Mysore. It is suitable for both multi and bi-voltine races. Leaves are big in size, high protein content and more succulent. It has high photosynthetic efficiency. Yield per hect/year is 67 MT it depends on the type of soil, climate, availability of water, specific variety of mulberry for each region should be selected for higher yield.



Figure 17: S-36.



Figure 18: V₁.



Figure 19: S-13.



Figure 20: S-34.

Different Uses of Mulberry

Man's dependence on plants for his existence dates back to the beginning of the human race. In the early days, he had only limited needs like food, shelter and clothing but with the

advancement of civilization, his requirements also grew. The present day man depends heavily on a very large numbers of plants and animal produced to meet his daily needs. Chhattisgarh is a remarkable place, not only because of the tribal population and dense forest, but also having a lot of rare and useful natural resources including some rare species of medicinal plants which are used for curing different kinds of diseases. Mulberry is a deep-rooted perennial plant with highly branching root and shoot systems. Mulberry belongs to the family moraceae. In Japan, more than 1000 varieties are stored and in India at the CSTRI Mysore, there are about 400 mulberry varieties of which 85 are indigenous, 114 are exotic origin. Some of the important medicinal values of mulberry plants are it contains different chemical of medicinal value in leaf, fruit, stem and root portions. Mulberry can grow both in the tropics and in the temperate regions. It can be cultivated in different soil types. It can be raised both in rain-fed and irrigated conditions. It is comparatively resistant to environmental fluctuations and is relatively free from pests and diseases. Mulberry cultivation and sericulture have been practiced for a very long time. But in the past mulberry was cultivated more for its medicinal use than for rearing of silkworms alone.

1. Medicinal value of mulberry leaf

The leaves are simple, alternate, stipule and petiolate. Leaf may be glossy or scabrous in texture, leaf apex may be long tailed, acute or double acute. In some countries, mulberry leaves are directly used in preparing the tea or these together with the mulberry roots and stem are boiled to prepare a tea which is effective in lowering down the blood pressure. In Cambodia, mulberry leaves are used in the treatment of conjunctivitis. Mulberry leaves contain variety of chemical such as phenylalanine, leucine, valine, tyrosine, proline, alanine, glutamic acid, glycine, serine, arginine, aspartic acid, ascorbic acid, carotene, vitamin B, folic acid, folinic acid, vitamin D, Cystine. Accordingly, leaves of mulberry have great medicinal value. Mulberry leaves have been found effective in lowering the blood -sugar level and arterial pressure. These are also used in gargles for curing the throat inflammation. Moreover, the aqueous and alkali extract of mulberry leaves are active against gram-positive bacteria and yeasts. Some rural people use mulberry leaf as food because of being highly nutritious. Several compounds of calcium, phosphorus, silicon, manganese, magnesium, iron, copper, zinc and vitamin are found in abundance in mulberry leaves. In view of this, it has been seen that mulberry leaves provide excellent material for preparing paratha, pakoda, as compared to spinach. As like pea, cucumber etc. man also now consumes mulberry leaves as vegetable. The mulberry leaves, satisfy the dietary requirement of human beings and contain all the elements required for the body.

2. Medicinal value of fruits

The fruit of mulberry is a multiple one, as all the flower of the inflorescence give rise to a single fruit. The fruit is green but changes to purplish through various shades of pink, red,

brown, etc. due to certain water contained in the juice. It is also good for brain, heart, spleen and helps curing diarrhoea and intestinal ulcers. It is considered as a laxative and oral juice administration good drink after a febrile illness. Mulberry fruit is well known as esteemed dessert fruit and having high source of vitamin 'C' which is commonly used for the jams, Jellys, cooling beverages and wines. The fruit has special taste and attracts women who are on their family way. This is due to vitamin C, which gives a sour taste and makes them chew the fruit repeatedly.

Table 22: Constituents of Mulberry Leaf

S. No.	Parameters	Percentage
1.	Contains moisture	85 per cent
2.	Proteins	0.7 per cent
3.	Fats	0.4 per cent
4.	Carbohydrates	12.2 per cent
5.	Calcium	80 mg
6.	Phosphorous	20 mg
7.	Iron	2.6 mg

Carotene, vitamin A, thiamine, nicotinic acid, riboflavin and ascorbic acid in trace amounts. Besides, these, it contains malic acid, citric acid, pectin, mucilage and colouring matter.

3. Medicinal value of root

Mulberry is a deep rooted perennial plant its root system is very well developed though the growth and spread of the root depend upon the texture of the soil the root shows the same structure as in other dicotyledonous. The bark of root is bitter and possesses cathartic, antihelmintic and stringent properties. It is also used as restorative tonic and as remedy for nervous disorders in China. An alkaloid deoxynojirimycin [DNJ] has been extracted from the root bark of the black mulberry, *M. nigra*, which resembles glucose and interferes with the synthesis of sugar chains. The chemical hinders the addition of sugar molecules to the outer coat of the human immunodeficiency virus. Mulberry root juice has the capacity of agglutinating the blood. The medicine prepared from the root is called glucosidae which can be administered to the patients suffering from high blood pressure.



Figure 21: Mulberry products

2.3 Silkworm Seed Organization and its Significance; Seed Areas (Bivoltine and Multivoltine) Selected Seed Rearers and Silkworm Seed Legislation Act; Silkworm Races: Classification - Geographical Distribution on the Basis of Voltinism, Moultnism, Indigenous, Exotic, Multivoltine and Bivoltine

Introduction to Seed Organization

Silkworm seed: The silkworm layings are called seeds (eggs). Organization is principally involved in production and distribution of high quality mulberry silkworm seeds and implementation of the provision of CSB (Amendment) Act 2006 apart from many other important allied activities. National silkworm seed organization is a separate entity under CSB. It has a mandate to maintain, multiply and supply authorized silkworm stocks production and supply of quality industrial silkworm seeds and transfer of technologies in the field to improve productivity and quality silk.

Definition:

- » “Seed organization can be defined as structural production of silkworm P1 seeds for raising seed crop s successfully to support the project commercial seed production”.

- » Seed organization consists of maintenance of breeder stock and its multiplication for the ultimate production of large quantity of commercial hybrid seeds.
- » Three distinct level of handling and multiplication of silkworm races are involved in seed production, namely breeder`s stock,, basic seed multiplication, and industrial seeds.
- » The maintenance of breeder`s stock should be the responsibility of breeder`s of Research Institute, which in turn should supply the basic seed for further multiplication.
- » The breeder`s stock will be multiplied 3-4 times in a year and the different multiplication levels are designated as P3, P2 and P1.
- » However, a three tier system is considered more ideal and effective which is followed in all sericultural advanced countries.
- » The breeder`s stock and multiplication centres should be under the control of govt. agencies and well trained persons.

Silkworm seeds:

Silkworm`s laying are called (eggs) seeds and they are of two types

1. Commercial seeds or Industrial seeds
2. Reproductive seeds or Industrial seeds

1. Commercial seeds:

Are generally specific hybrids between two or more silkworms and are reared for producing cocoons on a commercial scale for reeling. The race of the parent, the date of egg laying, the expected date of hatching and certificate that they are disease free should accompany these seeds. The commercial seeds are produced in special organisation called Grainages.

2. Reproductive seeds:

Are those that are used for the purpose of producing parents of the seeds used for commercial seeds. The purpose of the production of this kind of seed is for maintaining racial purity. They are produced only in special breeding centres by technically qualified persons. Reproductive seeds are often multiplied in number in a series of breeding centres called Breeding Stations or Farms in three or four stages in order to ensure that the racial characters are not diluted during the multiplication stages.

What is seed organization?

Basic and Commercial silkworm seed support the National Silkworm Seed Organisation (NSSO) Bangalore(Karnataka) has a network of 2 Zonal Silkworm Seed Organisation (ZSSO) at Malda (WB) and Dehradun (Uttarakhand).

- » 20 Silkworm Seed Production Centre
- » 20 Basic Seed Farms
- » 3 Seed procurement centres and
- » 32 sericulture service centres located at various places in the country.

The basic seed farms supply parent seed to the department of sericulture in various states on their requests.

Silkworm Seed Act in Karnataka

1. The Mysore Silkworm Diseases Control Act, 1943 (Mysore Act VIII of 1943).
2. The Mysore Silkworm Seed (Control of Distribution) Act, 1952 (Mysore Act XXXIII of 1952).
3. The Madras Silkworm Diseases (Prevention and Eradication) Act, 1948 (Madras Act II of 1948).
4. The Madras silkworm seed (production, supply and distribution) act, 1956 (Madras Act XXIII of 1956).

Breeding Station and or Farms

Silkworm seed organization in Karnataka

Karnataka is the leading state in the country in terms of silk production. It is also known as “silk bowl and “Garment Capital of India “because Karnataka`s industry contributes 20% of the garment production taking place in the country.

- » These are the stations where reproductive seeds are produced.
- » The production of reproductive seeds is different from the production of commercial seeds.
- » Reproductive seeds are generally pure lines of both local and the high yielding races or rarely.

- » The parents to be used for commercial seed production are reared in the breeding station.
- » The no. of pure breed parents required for grainage are too large to be obtained by a single multiplication from the stock in the germplasm so generally a three stage multiplication is carried out (for bi-voltine-four) in order to preserve the racial characters and avoid mixing up of the races.
- » Each of these multiplications is carried out in different stations rather than the same place.

Basic Seed Farms

P4 and P3 Farms/Great Great Grand Parents/Great Grand Parents/Stations:

- » These stations are also called as Race Breeding Stations.
- » They are also the major germplasm bank of the races.
- » They are under govt. control and are the places where Great Great Grand Parents or the Great Grand Parents of the commercial grainages, seeds are multiplied.
- » Normally the seeds are multiplied in a three tier system starting from the P3 stations.
- » But exotic pure breed races bi-voltine as well as multi-voltine races have four tier multiplication systems.
- » In these stations only pure breeds and no hybridization is done except research purposes.
- » The aim of these breeding stations is to maintain purity of the races.
- » Rearing of each race is done separately by cellular method of rearing.
- » 25% of the best cocoons are selected and sent to the station at next lower level (P3) for multiplication.
- » The remaining cocoons are used in the station itself for preparing eggs called Breeder's stock.
- » P4 and P3 stations are located at the cooler part of the country which are ideally suited for bi-voltine rearing and where multi-voltine can also be reared.

Multiplication of Basic Seed Stock at P4 and P3

Procedure for multiplication of basic stock at P4 and P3:

- » Plan and programme the basic seed production based on the requirement of eggs for next level of multiplication. There should be an integrated programme to supply the eggs to various multiplication centers.

- » Prepare a flow chart and supply programme for one year in advance for effective monitoring of the production and supply of basic seed.
- » Brush 10-30 dfls of each breed in cellular batches (individual laying) depending upon their demand and supply of laying.
- » Count all the larvae after third moult and retain till spring.
- » Sort out dead pupae cocoons, malformed cocoons, stained cocoons, thin shelled cocoons etc. after the cocoon harvest.
- » Calculate the pupation rate for the number of larvae brushed. Deduct the number of Uzi infested larvae and muscardine effected if any, from the original number and calculate the pupation rate only for the remaining basic no. of larvae.
- » Take 50-60 cocoons at random in each batch and sex them, then record mass cocoon weight, shell weight and cocoon shell percentage separately for both male and female cocoons. Take the mean of both sexes in each batch. Calculate the mean of various characters.
- » Select only the batches above average for pupation in each race.
- » For every rearing the P3 laying should be obtained from P4 stock. The selected batches of each breed both in P3 and P4 are to be interbred or inter batch crossing for raising next generation.
- » Depending upon the required no. of dfls, keep the equal no of male and female pupae for egg production.
- » After egg laying mother moth are subjected for pebrine examination.
- » Make provision to preserve P3 and P4 eggs under different hibernation schedule.
- » Replace the breeder stock from breeders once or twice in a year.
- » P4 and P3 stations are the race breeding experimental stations and their aim is to maintain the purity of the races. 25% of the selected cocoons from P3 are sent to the P2 stations. The eggs produced in P3 centers are called breeders stock eggs.

P2 stations /P2 Farms/ Grandparents

- » These produce the foundation stock seeds and serve as the germplasm bank.
- » They get seed cocoons from P3 stations.

- » The multiplication of the pure breed race is also done and hybridization carried out.
- » The laying of each mother moth are reared individually and mounted separately by cellular method of rearing. So that there is no chance of mingling of racial character.
- » The P2 stations select 25% of their best cocoons each laying and send to the next station lower down for multiplication there.
- » The remaining is used either for replenishing the stock or for reeling.

Multiplication of the silkworm breeds at P2 stations:

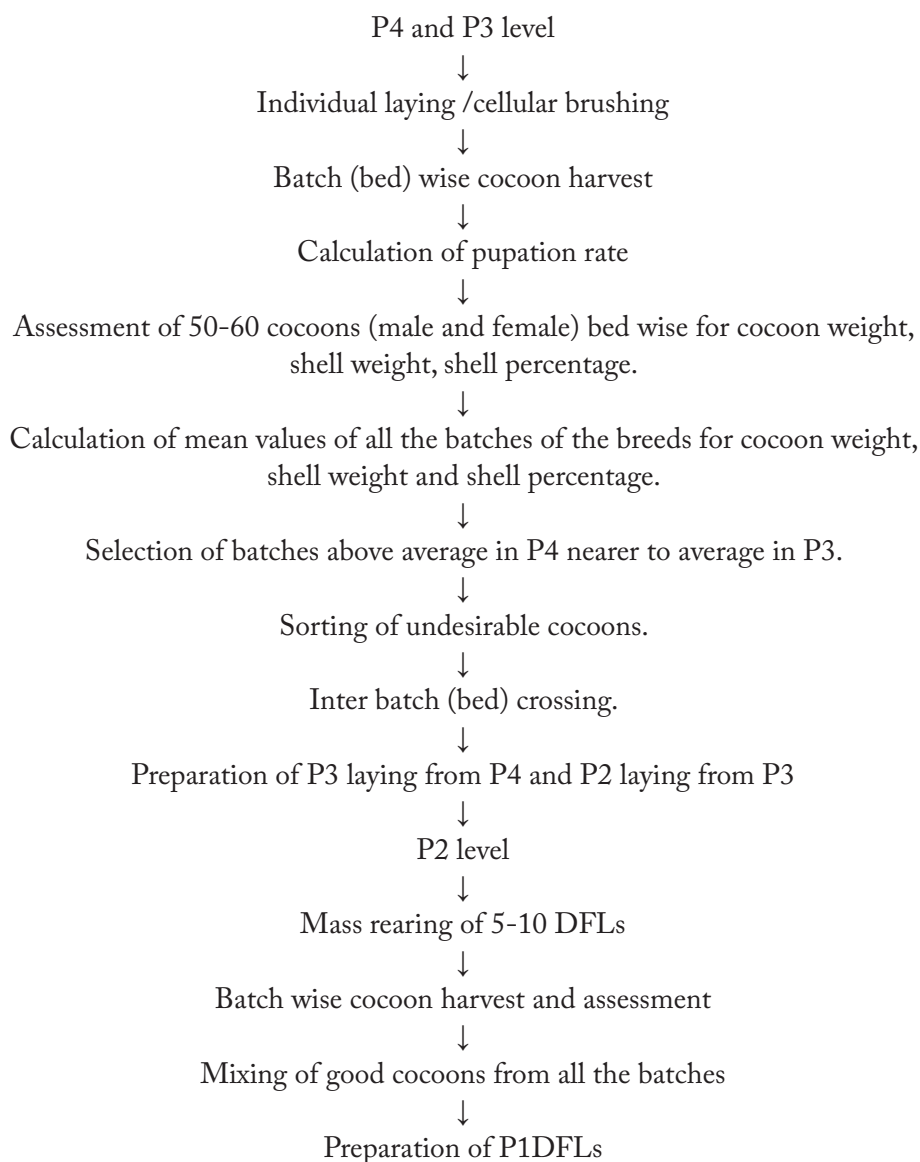
- » For every rearing, the P2 layings should be obtained from P3 stock.
- » Depending upon the requirement of P1 dfls the P2 dfls rearing should be prepared to produce 1000 P1 dfls, 6000 pupae are required, i.e. 3000 males and 3000 females. The survival rate is 50% of the total larvae brushed.
- » 5-10 dfls are brushed in mass.
- » After cocoon harvest sort out dead pupae cocoons, malformed cocoons, stained cocoons, thin shelled cocoons etc. live pupae cocoons are only taken for calculation of pupation rate.
- » Use mass cocoons assessment of 50 males and 50 females in each batch to record cocoons weight, shell weight and shell percentage.
- » Record data systematically.
- » Utilize all good cocoons for P1 laying production.
- » After egg laying the entire mother moth should be subjected for pebrine test individually.
- » Create data base systematically basic seed farms (BSF).

P1 stations / P1 Farms / Parents:

- » These are the stations where reproductive seed cocoons required by the grainages are reared (i.e. the parents of the commercial layings).
- » They receive the seeds from P2 stations.
- » The seed cocoons are mass reared and is the first hybridization of double cross is done here.

- » They send 25% of the grainages to seed cocoon rearers for the rearing of the seed cocoon which act as parents for the commercial layings. This system (three or four tier system) ensures that the racial characters are not diluted and sufficient stocks are maintained at each level of breeding.

Table 23: Flow chart of Multiplication of Basic Seed Stock at P4 and P3:



Need for seed organization

The most vital step in silkworm rearing is the production of eggs (seeds) required for rearing.

- » The silkworm eggs required for commercial rearing should be of high quality and free from disease.
- » The production and supply of disease free silkworm eggs is highly specialized work in involving technical and scientific skills.
- » To produce quality seed there must be a sound seed organization.
- » Realizing the importance of quality seed in the development of sericulture industry, seed organization and not conduct reaches on the technology of producing preserving, storing of supply of quality seeds but also import training in the technology of seed production to the grainage officials.
- » Therefore seed organization play a significant role in maintaining the basic seed purity its vitality (great energy) and vigourness test and are free from disease. The tested silkworm seeds are generally known as Dfls (Disease free layings) which are used for commercial rearing of silkworms.
- » The commercial laying or disease free layings are produced in silkworm seed stations known as Grainages and these are mostly controlled by govt. agencies.

Central silk board (CSB)

The CSB has been entrusted with overall responsibility of developing with overall covering the full gamut of sericulture activities in the country from the development of food plants to the production of fabrics including the formulation of policies governing import and exports. CSB was constituted during 1948. It is a statutory body presently under the administrative control of "Ministry of Textile" govt. of India. National Silkworm Seed organisation (Bangalore) established in 1975. The CSB has now grown into a big organisation to help in its coordination with the state and central agencies.

- » **NSSO:** (Mulberry seed) National Silkworm Seed Organisation (1975)
- » **BTSSO:** Basic Tasar Silkworm Seed Organisation (1999)
- » **MSSO:** Muga Silkworm Seed Organisation (1975)
- » **ESSO:** Eri Silkworm Seed Organisation (1975)

Beside, these organisations established the CSR& TI at Mysore in 1961 and other

at Berhampore (West Bengal). In J&K CSR&TI is located at Pampore district. These two institute have evolved a number of high yielding and disease resistance mulberry varieties such as; Kanva-2, S1, S30, S36, S40, and S54. These institutes evolved new multi-voltine cross breeds and bi-voltine silkworm races.

Silkworm Seed Organisation in Karnataka

Karnataka is the leading state in the country in terms of silk production. It is also known as “silk bowl and “Garment Capital of India “because Karnataka`s industry contributes 20% of the garment production taking place in the country.

Seed areas (Bi-voltine and Multi-voltine)

The P1 seed produced at P2 farm are supplied to the rearers in notified areas. Here they are allowed to rear only the pure races as per law. Such areas are declared by govt. as ‘**Seed area**’.

In Karnataka, there are 2 seed areas, one for multi-voltine and another for bi-voltine. In these areas all the farmers are enlisted as seed cocoons growers. They are given special training in rearing of pure races, the behavior of the silkworm races, and their care at different stages of growth, their feeding and mounting. Thus these groups of farmers are specialized in rearing pure races of silkworm growing seed cocoons.

Incentives are also given to these farmers in the form of special sub slides for improving their plantations, rearing houses etc.

Advantages:

1. The cocoons produced are subjected to test by the staff and only those crops which are certified as free from diseases and according to norms are allowed to be marketed as seed cocoons.
2. Labour requirement in rearing pure races is higher than cross breeds.
3. The larval growth is slow and requires more care.

Disadvantages:

1. In seed areas even the poorest farmer having hardly any land is also bound to rear pure races.
2. Cocoons of these farmers are of poor quality.
3. Many times disease broke out due to carelessness of such rearers.

Selected seed rearers

In Sericulturally advanced countries, egg producer is the supplier of P1-seed. He gets the required P1 farms and distributes them to the rearers, whom he feels, are having space, equipment and technical knowledge and confidence of rearing pure silkworms. These rearers are called “Selected Seed Rearers”.

These farmers need not be in seed areas on the other hand they are located in the areas where hybrids are reared. But these rearers are selected considering their mulberry garden for growing good quality leaf.

Maintenance of Hygiene During Pure Race Rearing

Either for commercial silkworm egg production farm or egg breeding station. Parent silkworms are those silkworms where eggs are to be taken for further egg production purposes. The cocoon thus harvested are called seed cocoon from which the F1- hybrid eggs are produced and distributed.

Most of the parental strain are pure lines, only a few being hybrid of different inbreed lines. It requires better feed, rearing environment condition and technical handling. Present silkworm rearing require a good development, strong physique and fine cocoon quality of the parent generation to produce a large quantity and good commercial silkworm eggs of F1- hybrid. In order to get good quality of F1-egg hygienic rearing is must which induce the following aspects:

1. Disinfection of rearing room and appliances

This is a preliminary operation carried out prior to the commencement of rearing as a precaution against pathogen which may remain in the room infecting the worm to be reared. The rearing room and appliances must be disinfected by spraying 2.4 % of formaldehyde solution. After spraying, the room is kept lightened for 15-16 hrs. then the doors and windows are opened and the room kept open for approximately 24 hr`s. for all traces of formaldehyde to disappear.

2. Brushing of newly hatched larvae

The process of separating the newly hatched larva from their egg shell and transferring them to the rearing bed is called brushing. For multi-voltine races the suitable time for brushing is at 8.00-9.00 hr's and earlier for multi-voltine.

3. Feeding

The quality of mulberry leaves effects the economic properties of the silkworm physique,

cocoon quality, egg quality, voltinism and Moulting. If the feed is not good during 1st to 3rd instar larvae, the larvae will suffer from insufficient supply of nutrient and their growth will be greatly affected.

4. Regulation of climatic condition

Since the climatic conditions including; temperature, humidity, air, circulating gases and light affects the growth and development of silkworm. These must be properly regulated for the perfect rearing.

5. Temperature

The rearing temperature directly influences the physiology of the silkworm intestinal tract, absorption, digestion, blood circulation and respiration. Generally, the temperature range for normal growth is 18-30 but optimum temperature must be 22-28°C.

6. Humidity

Humidity indirectly in larvae physiology thought the freshness of the seed and thus the sanitation of the rearing beds and the health of silkworm.

7. Bed cleaning

Cleaning of the rearing bed is much important for the hygienic rearing. It should be done before breeding. The faecal matter should be thrown away from rearing house.

Norms for the purchase of multi-voltine and bi-voltine seed cocoons:

Following are the norms which should be followed for the purchase of multi-voltine and bi-voltine seed cocoons which are as follows:

- » It should be free from Pebrine disease. If there is Pebrine spore the whole lot must be discarded.
- » Loose egg box should contain following information
 - Name of grainage.
 - No. of eggs/box and weight.
 - Date of release.
 - Probably date of hatching
 - There should not extra cost for incubation and supply of seeds.
 - Moth emergence should be synchronized.
 - Rate of moth emergence should be high.

Procurement of seed cocoon:

The seed cocoons arrive in lots from the seed rearers. The receiving selection first examines of the lot for conformity of the cocoons to the norms prescribed for the race.

- » It should be under ideal climate conditions and should be free from diseases for the purpose of reproduction.
- » It should show its all racial characters.

Cocoon Transportation

Cocoon transportation means transport of cocoons to grainages. Transport of cocoons to grainages is done only during the cool hours of the day i.e. early morning or late at night. These cocoons are loosely packed in plastic perforated crates/baskets are transported using seed cocoon transportation vehicles to avoid vigorous jerk and shaking of cocoons.

Perforated plastic baskets which hold around 8-10 kg of seed cocoons or perforated nylon bags are used for transportation. These help in minimizing the physical trauma to pupae, which results in increase melting at later stages. The transport should be done quickly and over short distances.

Silkworm Races: Classification - Geographical Distribution on the Basis of Voltinism, Moultnism, Indigenous, Exotic, Multivoltine and Bivoltine

Silkworm races:

Races: A population within a species i.e. distinct in some way especially a sub species.

There are two types of races

- » Indigenous races
- » Exotic races

1. **Indigenous races:** Originating and characteristic of a particular region or country native.

Example: Pure Mysore, Nistri.

2. **Exotic races:** Plants or animals species introduced into an area where they do not occur naturally, non native species.

Example: E16, DAIZO.

Geographical distribution of silkworm races:

Based on geographical distribution, races are classified into:

- » European races
- » Chinese races
- » Japanese races
- » Tropical races

Table 24: Major characteristics of different geographical races:

S. No.		Item	Chinese races	Japanese races	European races	Tropical races
1.	Egg	Colour	Grayish green	Grayish purple	Grayish brown and green.	Light yellow.
		Egg shell	Light yellow	White	White	White and shiny.
2.	Larva	Laval marking	Plain larva	Marked larva	No marking	No marking
		Larval duration	Long	Long	Long	Short
		Body colour	Whitish green	Light yellow	Yellow	Transparent, waxy yellow.
3.	Cocoon	Shape	Oval, spindle	Strangulate (peanut)	Elliptical	Spindle
		Colour	White, yellow, golden.	White, yellow.	White fleshy	White, green, golden yellow.
		Reelability	Good reelability.	Fine reelability.	Good reelability.	Poor reelability.
		Filament length	---	Short length.	---	Short length.
		Denier	Long length. Fine denier	Coarse denier.	Short length. Coarse denier.	Fine denier.
4.	Pupa and Moth		Pupae mostly black, moth with short wings.	Comparatively few eggs laid by one moth.	Comparatively more eggs laid by one moth than the others.	Wings mostly white.

Voltinism

Voltinism refers to the number of generation of an individual produced in a year.

Based on voltinism, races are classified into:

- » Uni-voltine
- » Bi-voltine
- » Multi-voltine

Table 25: Major characteristics of races

Uni-voltine races	Bi-voltine races	Multi-voltine races
Uni-voltine races produced one generation in a year.	Bi-voltine races produced two generation in a year.	Multi-voltine races produced more than two generations in a year.
Eggs laid remain in diapause till the next spring.	Laid non diapause eggs and diapause eggs.	Laid non diapause eggs.
Larval period is very long.	Larval duration is as long as Uni-voltine.	Larval duration is short.

Moultinism

Moulting is the process of shedding or casts off an outer layer or skin, which is replaced by new one. Based on moultinism, races are classified into:

- » Trimoulter
- » Tetramoulter
- » Pentamoulter

A. Trimoulter

This group includes silkworm which moult three times during its larval period.

B. Tetramoulter

This group includes silkworm which moult four times during its larval period.

C. Pentamoulter

This group includes silkworm which moult five times during its larval period.

Characteristics features of popular races of silkworm:

1. Pure mysore

The multi-voltine race is native of Karnataka state and is the counterpart of Nistari in the southern states.

- » It has long larval period. (About 27-28 days).
- » The cocoons are soft and flossy with an percentage of 18-22%
- » The single cocoon weight is 0.826gm. The shell ratio is 10-12%.
- » The length of the filament from a single cocoon is 411meter.
- » It has higher silk content and high renditta value (11-12).

2. Nistari

This is also called as Madrassi. This is one of the indigenous multi-voltine races.

- » The larva is small and spin spindle shaped, soft and flossy cocoons of golden yellow color.
- » The filament denier is only 1.7gms.
- » The weight of a single cocoon on the average is about 0.710gms.
- » The shell ratio is about 11-12%.
- » It was introduced in 1881 from china and continuous to dominate commercial rearing in the entire north India especially in west Bengal.

3. Kashmir race

This race is commercially famous.

- » Kashmir silk of the past was reeled from the cocoons of this multi-voltine race. It has now become extinct the white or colored cocoon were elongated oval in shape.

4. Kolar gold

This race is famous in Kolar district of Karnataka. It is poly-voltine race developed by CSRTI Mysore during 60s.

- » Low production breed but better than Pure Mysore and C-niche.

- » It is characterized by white elongated oval shaped cocoons with coarse grains.
- » It has poor post cocoon quality parameter but still better than Pure Mysore.
- » It has high renditta (10-11).

5. BL24

- » Develop by CSRTI MYSORE during 90s.
- » Higher cocoon yield than Pure Mysore.
- » Larvae are plain, generally yellow in color.
- » Cocoons are elongated oval shaped.
- » Cocoons of this race have coarse grains.

6. CSR2

- » It is 90's best bi-voltine race.
- » Plain larva with bluish white body color.
- » Bright white oval shaped cocoons with fine to medium grains.
- » Raw silk percentage 19- 20%.
- » Cocoon shell ratio 24-26%.
- » Fiber quality 2A~4A grade.

Concept of Breed and Hybrid

- » **Breed:** Stock of animals or plants with a species having homogenous appearance homo behavior and or other characteristics that distinguish other organism of the same species and that were arrived through selective breeding.
- » **Hybrid:** It is the process in which cross between two different species or variety that leads to the combination of new species reproductively isolated from the parent species.

Characteristics features of some breed and hybrid:

1. CSR2×CSR4

- » Parentage of CSR2: Shunrei × Shogetsu
- » Parentage of CSR4: Shunrei × Shogetsu

- » Year of authorization is 1997.
- » Plain larvae with bluish white body color.
- » Cocoons are bright white with intermediate shape and medium grains.
- » Better return for cocoon producer and reeler.
- » High cocoons shell ratio 22-24% and raw silk recovery 19-20%.
- » Better fiber quality 2A-4A grade.
- » Renditta: 5.6-6.1.

2. CSR2×CSR5

- » Parentage of CSR2: Shunrei × Shogetsu.
- » Parentage of CSR5: Shunrei × Shogetsu.
- » Year of authorization 1997.
- » Plain larvae with creamish white body color.
- » Cocoons are creamish white with intermediate shape and medium grains.
- » High cocoon shell ratio 23-25% and raw silk recovery 19-20%.
- » Better fiber quality 2A-4A grade.
- » Renditta: 5.6-6.1.

3. BL24×C.NICHI (VARUNA)

- » Year of authorization 2005.
- » Plain larvae with bluish white in color.
- » Cocoons are light greenish yellow and intermediate in shape.
- » Renditta is about 8.
- » High survival and better productivity trait has been developed.

4. BL67×CSR101 (CAUVERY)

- » Year of authorization 2005.

- » Tolerant to high temperature.
- » Recommended for irrigated areas of south India
- » Renditta: 8-9.
- » Plain larvae
- » Cocoons are light greenish yellow elongated oval shaped with medium to coarse grains.

5. PM×CSR2 (KOLAR GOLD)

- » Characterized by its robustness.
- » Higher reelability as compared to PM ×NB4D2.
- » Larvae are plain and bluish white in color.
- » Cocoons are light greenish-yellow.
- » Hybrid cocoon with oblong shape.

6. (CSR2×CSR27) (CSR6×CSR26)

- » Parentage of CSR2: Shunrei ×Shogetsu.
- » Parentage of CSR27: Thaihei×Choan.
- » Parentage of CSR6: Shunrei×Shogetsu.
- » Parentage of CSR26: C135×N134.
- » Cocoon yield /100 Df's:60-70 kg.
- » The foundation crosses are more robust than single parents.
- » Quality seed cocoons with less defective cocoons can be ensured.
- » Egg no. over single hybrid is 12- 15 %.

2.4 Biology of Mulberry Silkworm: Egg, Larva, Pupa Adult; Prerequisites of Mulberry Silkworm Rearing; Mulberry Biology: Salient Features, Morphology, Taxonomy of Mulberry; Popular Mulberry Cultivars and Characteristics Feature of Different Varieties of Mulberry

Mulberry Sericulture

The larva of mulberry silk moth, *Bombyx mori* L. is a domesticated form which feeds exclusively on the leaves of Mulberry tree, *Morus alba*. The larva of mulberry silk moth grows for about 20-23 days feeding mulberry leaves.

Biology of Mulberry Silkworm

The insect producing mulberry silk is a domesticated variety of silkworms, which has been exploited for over 5000 years now. Generally the term silk refers to mulberry silk, because it contributes to 95% of world silk production and. All the strains/races reared at present belong to the species *Bombyx mori* L. That is believed to be derived from its ancestor (Mandarina silkworm), *Bombyx mandarina* Moore. *Bombyx mori* L. is domesticated silkworm, feeds on mulberry leaves belonging to family Moraceae. These are classified and identified as uni-voltine, bi-voltine, and multi-voltine races and they are of pure and hybrid strains. These worms are having been reared in dwelling and separate rearing houses. The worms produce long, continuous silk filament which is white or light yellow in color and it can be industrially reeled to produce raw silk. This silk has good commercial value.

Taxonomic Classification

Phylum	Arthropoda
Class	Insecta
Sub-Class	Pterygota
Division	Endopterygota
Order	Lepidoptera
Family	Bombycidae
Genus	<i>Bombyx</i>
Species	<i>mori</i> (L.)

Life Cycle

Life cycle of the silkworm consists of four stages *i.e.*, adult, egg, larva, and pupa. The duration of life cycle is six to eight weeks depending upon racial characteristics and climatic conditions. Multi-voltine races found in tropical areas have the shortest life cycle with the egg, larval, pupal and adult stages lasting for 9-12 days, 20-24 days, 10-12 days and 3-6 days, respectively. Seven to eight generations are produced in multi-voltine races. In uni-voltine races, the egg period of activated egg may last for 11-14 days; the larval period, 24-28 days; the pupal period, 12-15 days and the adult stage, 6-10 days. In nature, uni-voltine races produce only one generation during the spring and the second generation of eggs goes through a period of rest or hibernation till the next spring. In case of bi-voltine races, however, the second generation eggs do not hibernate and hatch within 11-12 days and produce second generation normally during summer and it is the third generation eggs which undergo hibernation and hatches in the next spring, and thus producing two generations in one year.

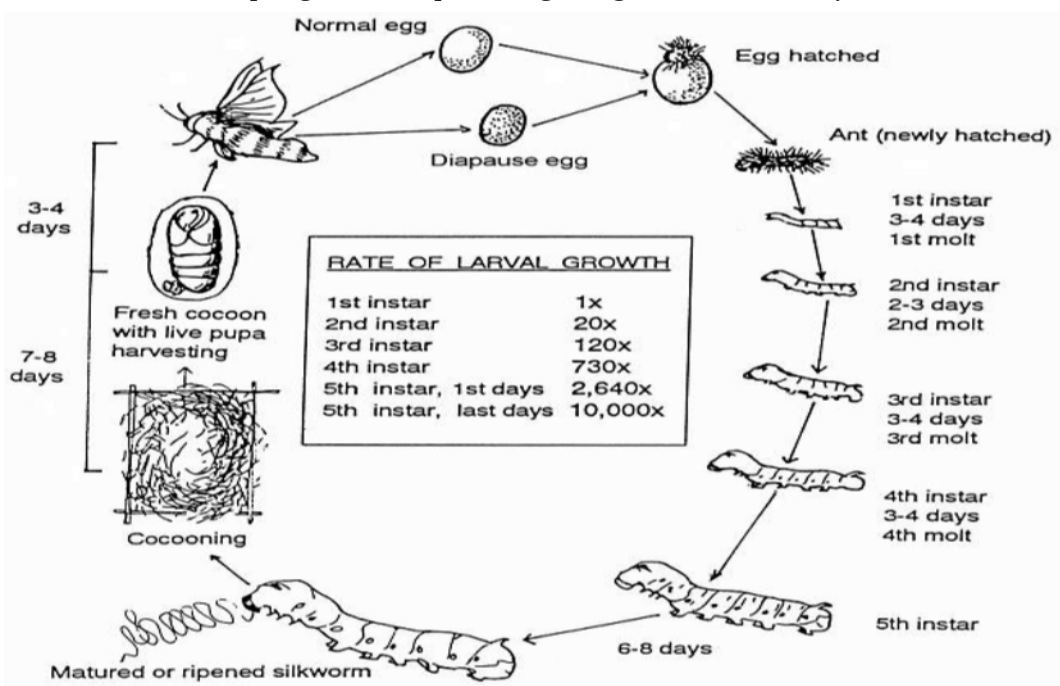


Figure 22: Stages of life history of mulberry silk worm *Bombyx mori*.

1. Egg

Silk worm egg is round and white. The weight of newly laid 2,000 eggs is about 1.0g. It measures 1-1.3 mm in length and 0.9-1.2 mm in width. With time, eggs become darker and darker. Races producing white cocoons lay pale yellow eggs; while races producing yellow cocoons lay deep yellow eggs. In case of hibernating eggs laid by bi-voltine and uni-voltine

As the egg matures, the egg color changes to dark brown or purple with the deepening of colour of the serosal pigments. The eggs may be of diapause or non-diapause type. The diapause types of eggs are laid by the silkworms inhabiting in temperate regions; whereas silkworms belonging to subtropical regions like India lay non-diapause type of eggs. During diapause all vital activities of the eggs cease.

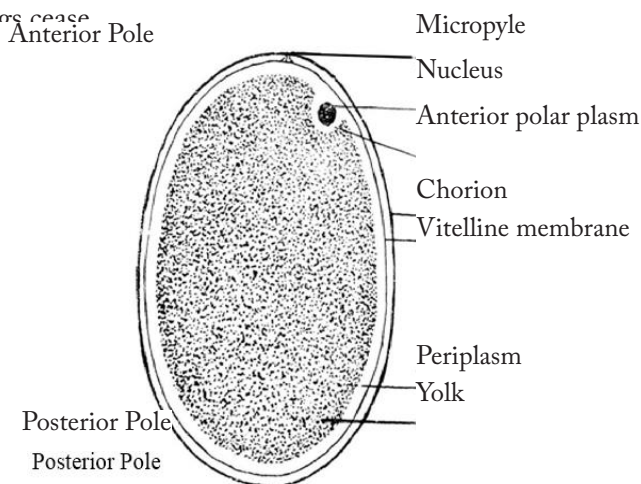


Figure 23: Structure of Silkworm Egg

2. Larva

After 10 days of incubation, the eggs hatch into larva called caterpillar. After hatching caterpillars need continuous supply of food, because they are voracious feeders. Newly hatched caterpillar is about 0.3 cm in length and pale yellowish white. The larval body is densely covered with bristles. As the larva grows, it becomes smoother and lighter in color due to rapid stretching of the cuticular skin during different instars of the larval stage. The skin consists of cuticle and hypodermis. Cuticle is made up of chitin as well as protein and is covered with a thin layer of wax, which is capable of being extended considerably to permit rapid growth of the larva during each instar. Nodules are found all over the surface of the body, and the distribution pattern differs according to the variety of silkworm. Larva bears four pairs of tubercles: sub-dorsal, supra-spiracular, infra-spiracular and basal tubercle. Each tubercle carries 3-6 setae. The larval body is composed of head, thorax and abdomen. The head consists of six fused segments. It carries the appendages: antennae, mandibles, maxillae and labium. Median epicranial suture, clypeus and labrum are well developed and prominent. Six pairs of larval eyes or ocelli are located a little above the base of antennae. Five segmented antennae are used as sensory organs. The mandibles are well developed, powerful and adapted for mastication. The maxillary lobe and palpi help in discriminating taste of food. The prementum is also chitinized, and its distal part carries a median process known as spinneret through which silk is extruded out from the silk gland. The sensory labial palpi are found on both sides of the spinneret.

The thorax has three segments: prothorax, mesothorax and metathorax. Each of the thoracic segments carries ventrally one pair of true legs, which are conical in shape and carry sharp distal claws. These claws are not used for crawling but they help in holding the leaves while feeding. Abdomen consists of eleven segments, though only nine can be distinguished, as the last three are fused together to form the apparent ninth segment. Third to sixth and last abdominal segment bear a pair of abdominal legs, which are fleshy, unjointed muscular protuberance. Eighth abdominal segment bears caudal horn on the dorsal side.

The abdominal segments carry the sexual markings on ventral side, which are developed distinctly during fourth and fifth instars in the eighth and ninth segments. In females, the sexual marking appear as a pair of milky white spot in each of the eighth and ninth segments and are referred to as Ishiwata's Fore Gland and Ishiwata's Hind Gland respectively. In males a small milky white body known as Herold's Gland appears ventrally in the centre between eighth and ninth segments. Nine pairs of spiracles are present: one pair on the first thoracic segment and eight pair's one on each side of the first to eighth abdominal segments, respectively.

The larval growth is marked by four moultings and five instar stages. The full-grown caterpillar develops a pair of sericteries or silk glands. Sericteries or silk glands are modified labial glands. These glands are cylindrical and divided into three segments: Anterior-, middle- and posterior-segments. The inner lining cells are characterized by the presence of large and branched nucleus. These glands secrete silk which consists of an inner tough protein, fibroin, enclosed by a water soluble gelatinous protein, sericin. In *Bombyx mori* L. the fibrinogen which on extrusion is denatured to fibroin is secreted in the posterior segment of the gland and forms the core of the silk filament in the form of two very thin fibres called brins. The sericin, a hot water soluble protein, secreted by middle segment of the gland, holds the brins together and covers them. The duct from another small gland called Lyonnet's gland, that lubricates the tube through which the silk passes, joins the ducts of the silk glands. Finally, the silk is moulded to a thread as it passes through the silk press or spinneret.

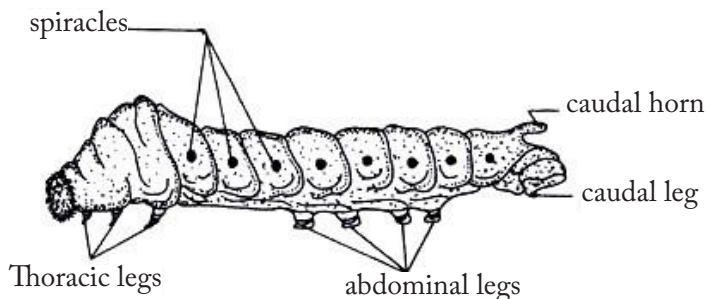


Figure 24: Mature larva of mulberry silkworm *Bombyx mori* L.

3. Pupa

Pupa is the inactive resting stage of silkworm. It is a transitional period during which definite changes take place. During this period, biological activity of larval body and its internal organs undergo a complete change and assume the new form of adult moth. The mature silkworm passes through a short transitory stage of pre- pupa before becoming a pupa. During the pre-pupal stage, dissolution of the larval organs takes place which is followed by formation of adult organs. Soon after pupation the pupa is white and soft but gradually turns brown to dark brown, and the pupal skin becomes harder.

A pair of large compound eyes, a pair of antennae, fore and hind-wings, and the legs are visible. Ten segments can be seen on the ventral side, but only nine are visible on the dorsal side. Seven pairs of spiracles are present in abdominal region, the last pair being non-functional. Sex markings are prominent and it is much easier to determine the sex of pupa. The female has a fine longitudinal line on the eighth abdominal segment, whereas such marking is absent in case of male. The pupa is covered within a thick, oval, white or yellow silken case called cocoon. The pupal period may last for 8-14 days after which the adult moth emerges slitting through the pupal skin and piercing the fibrous cocoon shell with the aid of the alkaline salivary secretion that softens the tough cocoon shell.

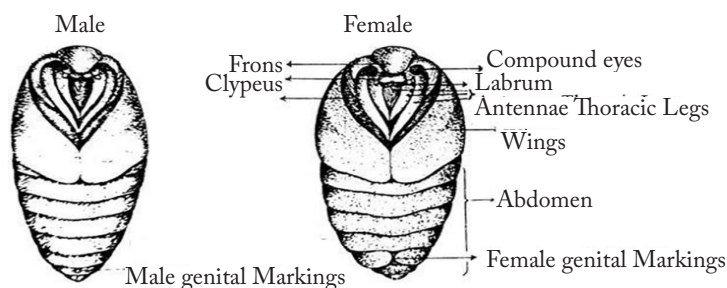


Figure 25: Pupae of mulberry silk worm *Bombyx mori* L.

4. Adult

The adult of *Bombyx mori* L. is about 2.5 cm in length and pale creamy white. After emergence the adult is incapable of flight because of its feeble wings and heavy body. It does not feed during its short adult life. The body of moth has general plan of insect body organization. The ocelli are absent. The antennae are conspicuous, large and bipectinate. The meso- and meta-thorax bear a pair of wings. The front pair overlaps the hind pair when the moth is at rest. The moth is unisexual and shows sexual dimorphism. In male eight abdominal segments are visible; while in female, seven. The female has comparatively smaller antennae. Its body and the abdomen are stouter and larger, and it is generally less active than male. The male moth possesses a pair of hooks known as harpes at its caudal end; while the female has a knob like projection with sensory hair. Just after emergence, male moths copulate with female for

about 2-3 hours, and die after that. The female starts laying eggs just after copulation, which is completed within 24 hours. A female lays 400-500 eggs. The eggs are laid in clusters and are covered with gelatinous secretion of the female moth.

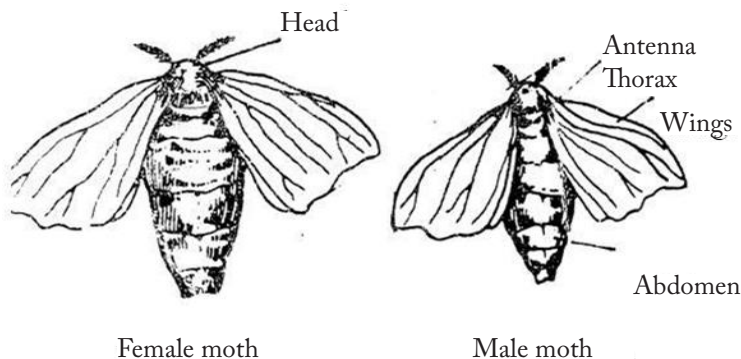


Fig 26: Adult moths of mulberry silk worm *Bombyx mori* L.

Rearing of Mulberry Silkworm

1. **Mulberry cultivation:** Cultivation of mulberry plants is called moriculture. There are over 20 species of mulberry, of which four are common: *Morus alba*, *M. indica*, *M. serrata* and *M. latifolia*. Mulberry is propagated either by seeds, root- grafts or stem cuttings, the last one being most common. Cuttings, 22-23 cm long with 3-4 buds each and pencil thick, are obtained from mature stem. These are planted directly in the field or first in nurseries to be transplanted later. After the plants have grown, pruning is carried out routinely which serves two purposes, induction of growth and sprouting of new shoots. Harvesting of leaves for feeding larva is done in three ways: leaf picking, branch cutting and top shoot harvesting. In leaf picking, individual leaves are handpicked. In branch cutting method, entire branch with leaves are cut and offered to 3rd instar larva. In top shoot harvesting, the tops of shoots are clipped and given to the 4th and 5th instars. The yield and quality of leaf depend upon the agronomic practices for cultivation of mulberry trees, namely irrigation, application of fertilizers etc. It is estimated that 20,000 to 25,000 kg of leaves can be harvested per hectare per year under optimum conditions. It has also been estimated that to rear one box of 20,000 eggs, 600-650 kg of leaves are required for spring rearing and 500-550 kg for autumn rearing in Japan. In India, to rear 20,000 eggs the quantity of leaves required is about 350-400 kg.

2. Rearing equipments:

- a. **Rearing house:** The rearing house should meet certain specification, as the silk worms are very sensitive to weather conditions like humidity and temperature. The rearing room should have proper ventilation optimum temperature and proper humidity. It should be

ensured that dampness, stagnation of air, exposure to bright sunlight and strong wind should be avoided.

- b. Rearing stand:** Rearing stands are made up of wood or bamboo and are portable. These are the frames at which rearing trays are kept. A rearing stand should be 2.5 m high, 1.5 m long and 1.0 m wide and should have 10 shelves with a space of 20 cm between the shelves. The trays are arranged on the shelves, and each stand can accommodate 10 rearing trays.
- c. Ant well:** Ant wells are provided to stop ants from crawling on to trays, as ants are serious menace to silk worms. They are made of concrete or stone blocks 20 cm square and 7.5 cm high with a deep groove of 2.5 cm running all round the top. The legs of the rearing stands rest on the centre of well filled with water.
- d. Rearing trays:** These are made of bamboo or wood because these are light in weight and easy to handle. These are either round or rectangular.
- e. Paraffin paper:** This is a thick craft paper coated with paraffin wax with a melting point of 55 °C. It is used for rearing early stages of silk worms and prevents withering of the chopped leaves and also helps to maintain proper humidity in the rearing bed.
- f. Foam rubber strips:** Long foam rubber strips 2.5 cm wide and 2.5 cm thick dipped in water are kept around the silkworm rearing bed during first two instar stages to maintain optimum humidity. Newspaper strips may also be used as a substitute. These are tapering bamboo rods (1cm in diameter) and meant for picking younger stages of larvae to ensure the hygienic handling.
- g. Feathers:** Bird feathers preferably white and large are important items of silkworm rearing room. These are used for brushing newly hatched worms to prevent injuries.
- h. Chopping board and knife:** The chopping board is made up of soft wood it is used as a base for cutting leaves with knife to the suitable size required for feeding the worms in different instar stages.
- i. Leaf chambers:** These are used for storing harvested leaves. The sidewalls and bottom are made of wooden strips. The chamber is covered on all sides with a wet gunny cloth.
- j. Cleaning net:** These are cotton or nylon nets of different mesh size to suit the size variations of different instars of the silk worm. These are used for cleaning the rearing beds, and at least two nets are required for each rearing tray.
- k. Mountages:** These are used to support silkworm for spinning cocoons. These are made up of bamboo, usually 1.8 m long and 1.2 m wide. Over a mat base, tapes (woven out of

bamboo and 5-6 cm wide) are fixed in the form of spirals leaving a gap of 5-6 cm. They are also called chandrikes. Other types of mountage such as centipede rope mountage, straw cocooning frames etc. are also used.

1. **Hygrometers and thermometers:** These are used to record humidity and temperature of the rearing room.
- m. **Feeding stands:** These are small wooden stands (0.9 m height) used for holding the trays during feeding and bed cleaning. Other equipments like feeding basins, sprayer, and leaf baskets may also be required.
3. **Rearing practices:** Silkworms must be reared with utmost care since they are susceptible to diseases. Therefore, to prevent diseases, good sanitation methods and hygienic rearing techniques must be followed. The appliances and the rearing room should be thoroughly cleaned and disinfected with 2-4% formaldehyde solution. Room temperature should be maintained around 25°C.

Procurement of quality seeds

The most important step in silkworm rearing is the procurement of quality seeds free from diseases. Seeds are obtained from grainages, which are the centers for production of disease free seeds of pure and hybrid races in large quantities. These centers purchase cocoons from the certified seed cocoon producers. These cocoons are placed in well-ventilated rooms with proper temperature (23-25°C) and humidity (70-80%), and emergence of moth is allowed. Grainage rooms may be kept dark, and light may be supplied suddenly on the expected day of emergence to bring uniform emergence. Emerging moths are sexed and used for breeding purposes to produce seed eggs. Three hours of mating secures maximum fertilized eggs. The females are then made to lay eggs on paper sheets or cardboard coated with a gummy substance. Egg sheets are disinfected with 2% formalin, and then washed with water to remove traces of formalin and then dried up in shades. The eggs are transported in the form of egg sheet. However, it is easy to transport loose eggs. To loosen the eggs, the sheets are soaked in water. The loose eggs are washed in salt solution of 1.06-1.10 specific gravity to separate out unfertilized eggs and dead eggs floating on surface. Prior to the final washing, the eggs are disinfected with 2% formalin solution. Eggs are dried, weighed to the required standard and packed in small flat boxes with muslin covers and dispatched to buyers.

Brushing

The process of transferring the silkworm to rearing trays is called brushing. Suitable time for brushing is about 10.00 am. Eggs at the blue egg stage are kept in black boxes on the days prior to hatching. The next day they are exposed to diffused light so that the larvae hatch uniformly in response to photic stimuli. About 90% hatching can be obtained in one day by this method.

In case of eggs prepared on egg cards, the cards with the newly hatched worms are placed in the rearing trays or boxes and tender mulberry leaves are chopped into pieces and sprinkled over egg cards. In case of loose eggs a net with small holes is spread over the box containing the hatched larvae and mulberry leaves cut into small pieces are scattered over the net. Worms start crawling over the leaves on the net; the net with worms is transferred to rearing tray.

Preparation of feed bed and feeding

After brushing, the bed is prepared by collecting the worms and the mulberry leaves together by using a feather. The bed is spread uniformly using chopsticks. The first feeding is given after two hours of brushing. Feed bed is a layer of chopped leaves spread on a tray or over a large area. The first and second instar larvae are commonly known as chawki worms. For chawki worms, paraffin paper sheet are spread on the rearing tray. Chopped mulberry leaves are sprinkled on the sheet and hatched larvae are brushed on to the leaves. A second paraffin paper sheet is spread over the first bed. In between two sheets water soaked foam rubber strips are placed to maintain humidity. The 4th and 5th instars are reared in wooden or bamboo trays by any of the three methods: viz., shelf-rearing, floor-rearing and shoot-rearing. In shelf rearing, the rearing trays are arranged one above the other in tiers on a rearing stand which can accommodate 10 -11 trays. This method provides enough space for rearing, but it is uneconomical as it requires large number of laborers to handle the trays. Chopped leaves are given as feed in this method. In floor rearing, fixed rearing sheets of 5-7x1-1.5m size are constructed out of wooden or bamboo strips in two tiers one meter apart. These sheets are used for rearing. Chopped leaves are given as feed. This method is economical than the first one because it does not involve much labour in handling of trays. Shoot-rearing is most economical of the three methods. The rearing sheet used is one meter wide and any length long in single tier and the larvae are offered fresh shoot or twigs bearing leaves. This method can be practiced both outdoors and indoors depending upon the weather.

Each age of the silk worms could be conveniently divided into seven stages i.e., first feeding stage, sparse eating stage, moderate eating stage, active eating stage, pre-moulting stage, last feeding stage, moulting stage. The larvae have good appetite at first feeding stage and comparatively little appetite at sparse and moderate eating stages. They eat voraciously during active stage to last feeding stage after which they stop feeding.

Bed cleaning

Periodical removal of left over leaves and worms' excreta may be undertaken and is referred to as bed cleaning. It is necessary for proper growth and proper hygiene. Four methods are adopted: conventional method, husk method, net method, and combined husk and net method.

Spacing

Provision of adequate space is of great importance for vigorous growth of silkworms. As the worms grow in size, the density in the rearing bed increases and conditions of overcrowding are faced. Normally it is necessary to double or triple the space by the time of moult from one to other instar stage, with the result that from the first to third instar the rearing space increases eight fold. In 4th instar, it is necessary to increase the space by two to three times and in 5th instar again twice. Thus, the rearing space increases up to hundred folds from the time of brushing till the time of maturation of worms.

Mounting

Transferring mature 5th instar larvae to mountages is called mounting. When larvae are fully mature, they become translucent, their body shrinks, and they stop feeding and start searching for suitable place to attach themselves for cocoon spinning and pupation. They are picked up and put on mountages. The worms attach themselves to the spirals of the mountages and start spinning the cocoon. By continuous movement of head, silk fluid is released in minute quantity which hardens to form a long continuous filament. The silkworm at first lays the foundation for the cocoon structure by weaving a preliminary web providing the necessary foot hold for the larva to spin the compact shell of cocoon. Owing to characteristic movements of the head, the silk filament is deposited in a series of short waves forming the figure of eight. This way layers are built and added to form the compact cocoon shell. After the compact shell of the cocoon is formed, the shrinking larva wraps itself and detaches from the shell and becomes pupa or chrysalis. The spinning completes within 2-3 days in multi-voltine varieties and 3-4 days in uni- and bi-voltine.

Harvesting of cocoons

The larva undergoes metamorphosis inside the cocoon and becomes pupa. In early days, pupal skin is tender and ruptures easily. Thus, early harvest may result in injury of pupa, and this may damage the silk thread. Late harvest has a risk of threads being broken by the emerging moth. It is, therefore, crucial to harvest cocoons at proper time. Cocoons are harvested by hand. After harvesting the cocoons are sorted out. The good cocoons are cleaned by removing silk wool and fecal matter and are then marketed.

The cocoons are sold by farmers to filature units through Cooperative or State Govt. Agencies. The cocoons are priced on the basis Renditta and reeling parameters. Renditta may be defined as number of kg of cocoon producing 1 kg of raw silk.

Post cocoon processing

It includes different processes to obtain silk thread from cocoon.

1. **Stifling:** The process of killing pupa inside cocoon is termed as stifling. Good-sized cocoon 8-10 days old are selected for further processing. Stifling is done by subjecting cocoon to hot water, steam, dry heat, sun exposure or fumigation.
2. **Reeling:** The process of removing the threads from killed cocoon is called reeling. The cocoons are cooked first in hot water at 95-97°C for 10-15 minutes to soften the adhesion of silk threads among themselves, loosening of the threads to separate freely, and to facilitate the unbinding of silk threads. This process is called cooking. Cooking enables the sericin protein to get softened and make unwinding easy without breaks. The cocoons are then reeled in hot water with the help of a suitable machine. Four or five free ends of the threads of cocoon are passed through eyelets and guides to twist into one thread and wound round a large wheel. The twisting is done with the help of croissure. The silk is transferred finally to spools, and silk obtained on the spool is called the Raw Silk or Reeled Silk. The Raw silk is further boiled, stretched and purified by acid or by fermentation and is carefully washed again and again to bring the luster. Raw Silk or Reeled Silk is finished in the form of skein and book for trading. The waste outer layer or damaged cocoons and threads are separated, teased and then the filaments are spun. This is called Spun Silk.

Mulberry Biology: Salient Features, Morphology, Taxonomy of Mulberry; Popular Mulberry Cultivars and Characteristics Features of Different Varieties of Mulberry

Characteristics feature of different varieties of mulberry

Mulberry trees are perennial, live for number of years either in cultivated or wild conditions. The branching nature of a plant is influenced by type of cultivation, mode of training, soil fertility, rainfall and environmental conditions. However, profuse branches are must for producing more amount of leaf so as to feed silk worms. The mulberry can be grown under various types of climatic conditions. Mulberry leaf protein is the source for the silk worm to bio-synthesize the silk which is made up of two proteins, fibroin and sericin.

Salient features of mulberry

Mulberry plant is distributed all over the world. It can be grown in temperate regions and tropical zone. Mulberry cultivation is adapted Japan, China, S. Korea, Russia, India, Brazil, France, Spain, Greece, Turkey, Sri Lanka, Egypt, Syria, Burma, Poland, Thailand, Bulgaria, Vietnam, Bangladesh, Afghanistan, Rumania, Indonesia, etc. The sericulture belt can be divided into two zones in the world.

- i. Temperate
- ii. Tropical zone

The countries fall under temperate zone producing univoltine cocoons are Japan, China, Korea, Northern India, Burma, Iran, Turkey, South of Rumania, Lebanon, Greece, Rumania, Bulgaria, Hungary, Yugoslavia, Spain, Italy, France and Poland. The tropical zone stretches from 30°C north latitude and contains polyvoltine silk worms.

India the only country to produce all the four types of silk viz., Mulberry, Tasar, Eri and Muga 90% of silk produced in India is Mulberry. Karnataka, Andhra Pradesh, West Bengal, Tamil Nadu and Manipur states are at the top under Mulberry area known as Philippine variety. Kadambi (1949) reported that many of the Mulberry varieties were introduced into India from China, Europe, Japan or Philippines. Mukerjee (1899) described *Morus laevigata* and *M. indica* are the varieties of *M. laevigata* and *M. Serrata* as a separate species and regarded the *M. Laevigata*, *M. Sinensis*, *M. Philippinensis*, *M. Multicaulis* and *M. indica* as varieties of *M. alba*. Based on the principles of classification made by Hotta (1954), Gururajan (1960), all the cultivated forms of Mulberry are divided into three species.

1. *M. latifolia* - This includes mulberry tree grown in U.P. and Kashmir.
 2. *M. alba* - This includes mulberry bushes cultivated in Tamil Nadu and Mysore.
 3. *M. bombycis* - This includes Berhampore variety.
1. ***Morus alba***: Cultivated in Punjab, North, and West Himalayas ascending to 3500 m. The trees grow to height of 10-15 m. and of wild and cultivated for their fruits and timber.
 2. ***Morus indica***: Most of the Indian of mulberry belong to this species. They are moderate size deciduous trees, distributed in the lower Himalayan and sub-Himalayan tracts from Kashmir to in the other regions in India, particularly in Assam in the north east and in southern plateau in Karnataka and Tamil Nadu ascending up to 1500M. There are several varieties falling under this species, raised mostly as bushes.
 3. ***Morus serrata***: This species grows as trees up to height of 20 to 25m with a trunk girth of about 9 mt. In temperate Himalayas from Kumaon Hills west ward, upto an attitude of 3000m.
 4. ***Morus laevigata***: This species is distributed in tropical regions from Indus valley to Assam wild cultivated ascending to 1500 m.

Morphology of mulberry

Mulberry belongs to the family Moraceae and Genus *Morus*. Each species shows some variations. According to Hoocer (1985) the description of the genus *Morus* is as follows:

1. **Habitat:** Mulberry grows as a tree or shrub, but in cultivation it is raised as bush by pruning. The plant is perennial, with highly branching root and shoot system with primary, secondary and tertiary branches. The branching character varies from type of cultivation, mode of training, rainfall and fertility of soil, up to the height of 22-25 mts. With girth about 8 mts.

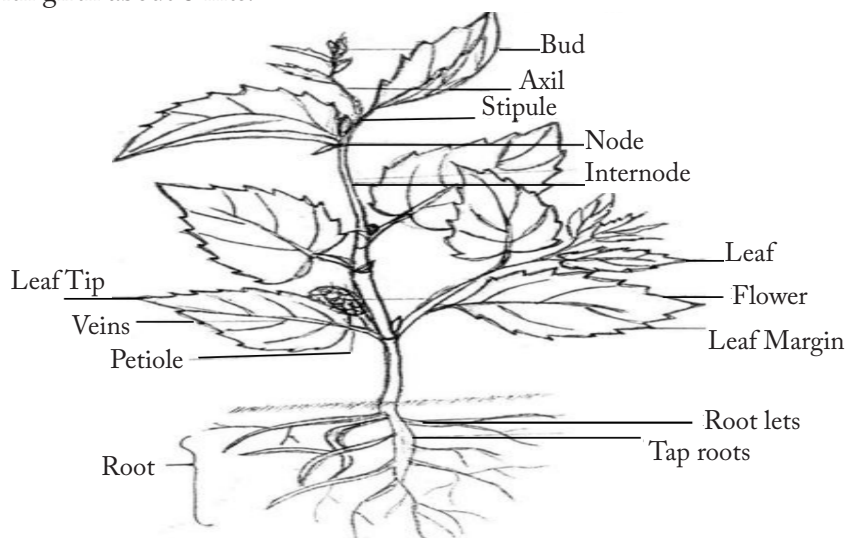


Figure 27: Mulberry plant

2. **Stem:** The colour of the bark is varies from green, grey to pink or brown. Color varies and depends upon the species, climate and origin. Mysore local, K2, Berhampore local are white to grayish white in color. Each axial of a leaf has a bud. Sometime two or more buds on sides are shown and are called accessory buds. Buds are protected by the covering of young leaves. The growing points emerging as a shoot under favorable climatic conditions. The buds are two types – vegetative and reproductive buds.
3. **Leaf:** The leaf size, shapes of Mulberry varieties are different. The hybrid leaves such as Kanva -2, S 54, S 36, S 30, S 34 are characterized by large leaves, while Mysore local bear small leaves. The leaves are simple, alternate, stipulate and petiolate. The stipule protects young leaf, as leaf matures the stipule drops out. The leaf may glossy; texture of the leaf may be entire or lobed or rarely of both types are found on the same twig. The leaf lamina is usually glabrous. The thickness of the leaf is about 100-200mm. The shape of leaf may be cordate or straight. The leaf tip is acute. The leaf margin may be serrate, dentate. The venation of the leaf is multicostate, reticulate. The leaf surface epidermal cells covered with cuticle and upper epidermal contains idioblast cells. It contains cystolith, non crystalline lime, CaCO_3 are present.
4. **Inflorescence:** In mulberry inflorescence is a catkin more than ten flowers grow around

rachis, being attached to the axial of new shoots. This type of inflorescence is called spike or catkin. The peduncle bearing unisexual flowers, the inflorescences is auxiliary.

5. **Flower:** The male flowers are loosely attached to the peduncles. The flower consists of four perianths, leaves arranged in two whorls with imbricate aestivation. The leaves are green. The margins and other surface of perianth provided with hairs. The stamens are four, arranged opposite to perianth leaves. Each stamen has a broad filament and narrow top on which two anther lobes are fixed. The pollen grains are round, dry, light and dust like with smooth exine. When bud opens, become straightened suddenly and androecium opens with great force and pollens are scattered from the anther. After pollination male catkin becomes pink, dries and drops off as whole. The female flowers also got similar number of parianth leaves arranged in same manner as in male flower. These leaves persist in the fruit the fertilization stimulates the female flower parianth material and contribute to form the fruit. The ovary is superior, bicapellary, syncarpus. Oval, unilocular, with a single pendulously ovule attached to the margin of the ovary and has a bifid stigma. The length of the style is botanically significant character in identifying various species of Mulberry. After pollination and fertilization the entire inflorescence becomes a multiple fruit.

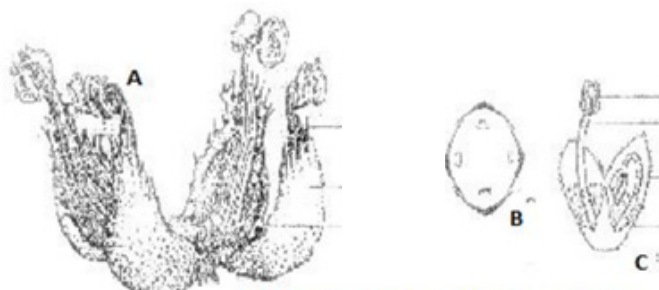


Figure 28: A) Male Flower B) Floral Diagram C) Longitudinal section of male bud

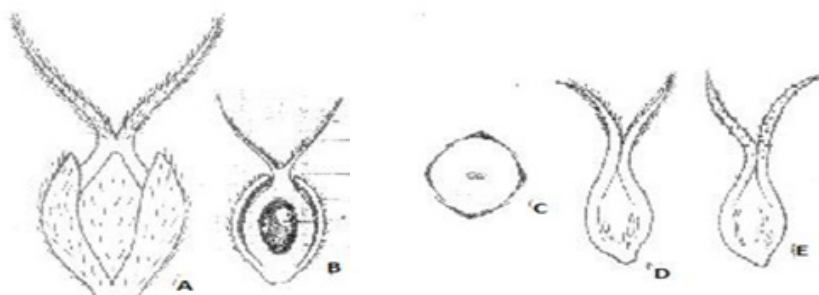


Figure 29: A) Female Flower B) Longitudinal section of Female bud C) Floral Diagram, D) Stigma Pubscent E) Stigma Pappilose

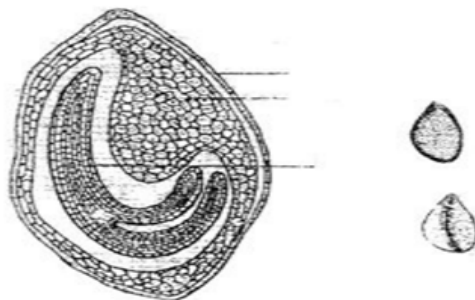


Figure 30: A) Mulberry seed B) Side view C) Longitudinal section



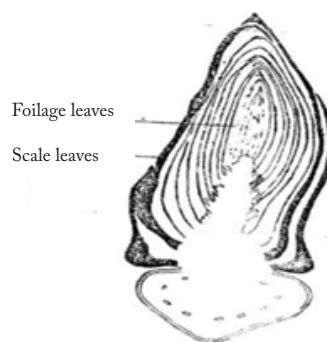
Figure 31: Female catkin,



Male catkin



Figure 32: Bud,



Longitudinal section of Bud

6. **Pollination:** In Mulberry cross pollination takes place by wind. After fertilization the style and stigma fall down and the ovarian wall swells and changes fleshy making fruit. It is called 'sorus'. After fruit formation, inner part of the ovarian wall becomes endocarp which shows lignifications and covers seed. The sorosis is green in color at first and later becomes red and dark purple. The seed in dark purple – colored sorosis gets the ability to germinate effectively. The fruits are ovoid to sub-globules in shape measuring 5 cm in length.
7. **Seeds:** The mulberry seed is oval shaped with flat surface at the micropyle region. On one edge an elongated streak hilum is found. The end of hilum has a small pore known as

micropyle through which seed absorbs water when soaked. The seed coat has two layers, outer hard and brittle testa and inner tegma. The embryo has a primary axis and two cotyledons. The diploid species seeds weight is less than polyploid seeds. The mulberry seeds are available for longer period at low temperature (5°C) and low relative humidity.

8. **Root:** The Mulberry root has taproot, lateral roots and root hairs. The hairs are confirmed to top of the root. The root surface has many lenticels. The root hair absorbs water and nutrients from soil and lateral and tap roots transport and pressure water and nutrients. In general depending upon the soil condition the roots penetrate to a depth ranging from 10 cm to 50 cm.

Taxonomy of Mulberry

Mulberry belongs to plant kingdom, division phanerogammae, sub division Angiosperm, class dicotyledoris, family Moraceae. Mulberry belongs to the genus *Morus* there are 35 species of *Morus*. There are more than thousand species of plants belonging to the family Moraceae. It includes wild and cultivated forms, some of which are sterile. The method of classification of mulberry species should therefore be based on “Genome constituent”, an external characters like leaves, flowers and fruits etc., Ledebour (1846-1851) classified *Morus alba* and *M. nigra* on the basis of papillae and pubescences on the stigma, while Brandis (1996) classified the mulberry species into two sections by the length of its style. Hoho divided mulberry species into two groups on the shape and situation of cystolith cells in leaves. In India there are many kinds of species of which *Morus alba*, *Morus indica*, *Morus laevigata* and *Morus serrata* are widely growing in Himalayas. The classification of Indian varieties is also much confused. Based on principles of classification adopted by Hotta (1954), Gururajan (1960) suggested varieties of mulberry into three species i.e., *Morus alba* (Mysore, Tamil Nadu and A.P) *M. bombyis* (Berhampore variety) *M. latifolia* (Kashmir and U.P).

Taxonomic Classification

Kingdom	Plant kingdom
Division	Phanerogamee
Sub-division	Angiospermae
Class	Dictoyledons
Sub class	Monochlamydae
Series	Unisexuales
Family	Moraceae
Genus	<i>Morus</i>
Species	<i>Alba</i>

Characteristics of Angiosperms

The angiosperms more commonly known as the flowering plants, are categorized as a group by the presence of vessels in the stem, by the ovule enclosed within one or more capillary sporophylls and composing the ovary, this organs to get with its terminal stigmatic zone constituting. The basic elements of the gynoecia, the pistil, one or more micro sporangia born on a microsporophyll, composing the basis element of the androecium and the stamens or the combination of members of one or both of these sex elements.

1. Class Dicotyledions: The name Dictoyledions owes its origin to the typically two cotyledons present in embryos of members of this class. Plants are herbaceous or woody stems with vascular elements arranged either in a hollow cylinder around the relating small pith. In woody dicot stems the sheath of cambium is situated close to the bark between the xylem and phloem. Leaves are typically with netted venation of the palmate type and flowers are basically with parts in multiples of 4 or 5.

2. Sub class Monochlamydae: Embryo centered round the endosperm, ovule usually one.

3. Series Unisexuales: Flowers are unisexual.

4. Family Moraceae: In Moraceae the inflorescence of each sex is condensed into a pendulous a mentiferous structure. Inflorescence is reduced to globose head. Peduncles have become coalesced and dorsi ventrally compressed into a laminated receptacle over. The family is characterized by the presence of milky latex, and single ovule.

History and Distribution of Non Mulberry Silkworm in India and Other Countries; Status of Non Mulberry Silk Industry; Sericulture Development in North-Eastern States

Introduction

The natural silks are broadly classified as mulberry and wild or non-mulberry. Non-mulberry sericulture is universally known as forest or wild sericulture. Tropical and temperature tasar, eri, muga are the principle non-mulberry silks. Other varieties i.e. fagara, coan, mussel and spider silks are limited interest, nearly 95% of the global production of non-mulberry silks is tasar. All branches of sericulture require food plants and manpower. In mulberry sericulture over 60% of the cost of production goes into raising and maintaining the food plants, besides a heavy initial investment is necessary for rearing houses, rearing appliances and other essentials. Likewise, among the non-mulberry varieties, eri has the disadvantage of higher production costs. Tasar is endowed by nature with vast potential. Non-mulberry sericulture is a forest-based industry uniquely suited to the economy and social structure of developing countries

because of its minimum investment requirement, high employment, and foreign exchange earning potential. In India about 12, 43 million hectares of unexploited tasar food plants in the tropical and temperate belts could be put to use without investment. Moreover, unlike large industries in which heavy investment is indispensable and the employment potential is limited, tasar culture requires a very low investment for net high returns. Various operations of tasar production can be carried out even in remote forest villages as they do not require electricity, complex machinery, specialized skills etc. Non-mulberry production offers rural populations an attractive source of income; arrest their migration to urban areas, thereby preserving their traditional skill and way of life.

History

Vanya sericulture remained obscure for a long time as an exclusive craft of tribal and hill folks inhabiting the Central and North Eastern India. It is in the recent past that this tribal tradition assumed importance and attracted attention at National level. The rich production potentialities within the country, steady demand for vanya silk products outside, eco-friendly nature of the production and processing activities, women participation, promoted commercial exploitation of this craft, which culminated in the transformation of this age old tradition to an industry of immense potentiality. Vanya silks have been commercially exploited way back in 17th Century. The Western World gained an appetite for these alien shaded silks in mid-1800 when a rampant silkworm disease destroyed the European sericulture industry. Asia could not supply enough mulberry silk to cater to the needs of Europe and North America, thus creating a market for vanya silks.

- » **Tasar:** Though there is no recorded document available regarding the origin of tasar in India, one can find the mention of tasar silk in ancient epic Ramayana “Ram’s nuptial gift to Sita includes tasar silk”. Temperate tasar is of recent origin and was introduced during mid 1960’s.
- » **Muga:** The silk of Assam (Muga) was made known to the World during 1662 through a famous European traveller Jean Joseph Tavenier. Sericulture was exempted from payment of land revenue as the Kings of Assam patronised the development of sericulture. Around 1950, there was a great earth quake in Upper Assam and the large number of muga plantations was destroyed, which hampered the growth of muga industry.
- » **Eri:** The word eri means castor plant, is derived from the word “eranda” of Sanskrit origin. The advent of Ericulture is lost into the antiquity but, the fact remains that Assam was the original home of eri silk from time immemorial, with the earliest reference documented in 1779. The Britishers called it as “Palma Christi” silk. The eri silk was woven into heavy clothes known as “Bar Kapoor”. Captain Jenkins (1771) remarked that eri silk was of incredible durability.

Distribution

A large number of species (400-500) are used in the production of non-mulberry silks. But only eight have been commercially exploited in Asia and Africa tribal communities. They are Tasar silk, Muga silk, Eri silk, Anaphe silk, Fagara Silk, Coan silk, Mussel silk and Spider silk. Non-mulberry silks are commercially produced mainly in China and India. However major share of production (80%) goes to China. Climate and vegetation provide India with an abundance of non-mulberry sericigenous fauna. India produces significant amounts of all the important varieties of non-mulberry silks, tropical and temperature tasar, eri and muga.

Non - Mulberry Sericulture in the World

In addition to the domesticated or mulberry silkworm, *Bombyx mori*, many indigenous wild silkmoths species have been utilized for over 2000 years (Peigler, 1993). Wild silkmoths cocoons are collected from the wild population and in some cases, rearing is done outdoors with little or no protection of larvae (Peigler, 1993; Kioko et al., 2007). Non-mulberry sericulture holds great promise for the world's forestry and can help arrest forest destruction, as it permits gainful utilization of its natural wealth (Jolly et al., 1975; Fening et al., 2008). About 25 species of wild silkmoths have been exploited for wild silk production in the world, and this has been done mainly by tribal communities as reflected in some of the names of the silk (Peigler, 1993; Raina, 2000). According to Peigler (1993), India is the foremost country in the production of wild silk (Eri, Muga and Tasar) mainly for reasons being historical, cultural and economic. Wild silk varieties obtained globally include the Asian wild silk (Muga, Tasar, Fagara and Eri), the European silk (Coan) and the African wild silk obtained from indigenous wild silkmoths belonging to the genera *Anaphe*, *Gonometa*, *Argema* and *Epiphora* (Mbahin et al., 2008; Ngoka et al., 2008; Fening et al., 2008; 2010).

Table 26: Distribution of Non-Mulberry Silkworms in World

Name of species	Family	Distribution
<i>Antheraea mylitta</i> Drury	Saturniidae	India
<i>Antheraea roylei</i> Moore	Saturniidae	India, China
<i>Antheraea yamamai</i> G & M	Saturniidae	Japan, Taiwan
<i>Antheraea pernyi</i> G & M	Saturniidae	China, India
<i>Antheraea assamensis</i> Helfer	Saturniidae	Assam (India)
<i>Samia Cynthia ricini</i> Drury	Saturniidae	China, India, Japan, Cuba, Egypt, France, Italy

Distribution of Non-Mulberry Silkworms in India

1. **Tasar:** Tropical Tasar growing area forms a distinct belt of humid and dense forest sprawling over the Central and Southern plateau, covering the traditional states of Bihar, Jharkhand, Madhya Pradesh, Chhattisgarh, Orissa and touching the fringes of West Bengal, Andhra Pradesh, Uttar Pradesh and Maharashtra. Temperate tasar (oak tasar) extends from the sub-Himalayan region of Jammu and Kashmir in the West to Manipur in the East covering Himachal Pradesh, Uttarakhand, Assam, Mizoram, Arunachal Pradesh and Nagaland.
2. **Muga:** Assam accounts for more than 95% of the muga silk production. The culture is also spread in different districts neighbouring Assam in Meghalaya, Nagaland, Manipur, Mizoram, Arunachal Pradesh and West Bengal.
3. **Eri:** Eri culture was mostly confined to the Brahmaputra valley of Assam in the tribal inhabited districts, followed by Meghalaya, Nagaland, Mizoram, Manipur and Arunachal Pradesh. Eri culture is introduced on a pilot scale in States like Andhra Pradesh, Tamil Nadu, West Bengal, Bihar, Chhattisgarh, Madhya Pradesh, Orissa etc.

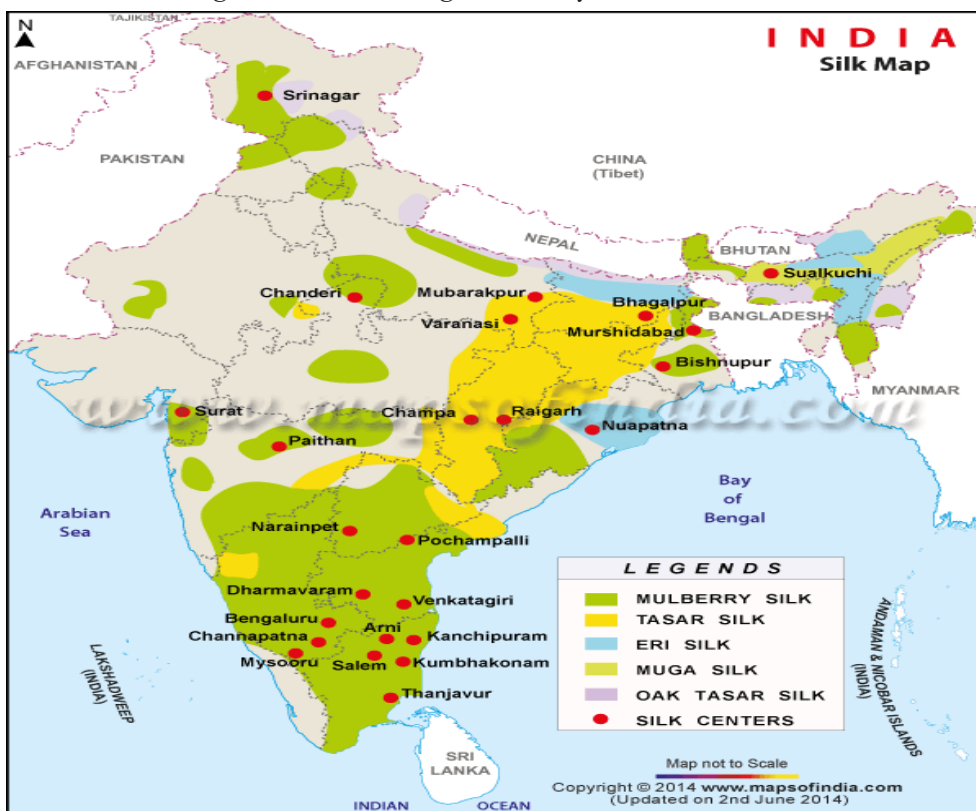


Figure 33: Map showing the distribution of Non-Mulberry Sericulture in India

Status of Non Mulberry Silk Industry

Silk is the most elegant textile in the world with unparalleled grandeur, natural sheen and inherent affinity for dyes, high absorbance, light weight, soft touch and high in durability. Because of these unique features silk is known as the “**Queen of Textiles**” the world over. On the other hand, it stands for livelihood opportunity for millions, owing to its high employment potential, low capital requirement and remunerative nature of its production. The very nature of this industry with its rural based on-farm and off-farm activities and enormous employment generation potential has attracted the attention of the planners and policy makers to recognize the industry among one of the most appropriate avenues for socio-economic development of a largely agrarian economy of India. Silk has been intermingled with the life and culture of the Indians. India has a rich and complex history in silk production and its silk trade which dates back to 15th century. Sericulture industry provides employment to approximately 8.25 million persons in rural and semi-urban areas in India. Of these, a sizeable number of workers belong to the economically weaker sections of society, including women. India’s traditional and culture bound domestic market and an amazing diversity of silk garments that reflect geographic specificity has helped the country to achieve a leading position in silk industry. 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 which is produced only in India with its golden yellow glitter is a prerogative of India.

The CSB has a chain of Basic Seed Farms supplying basic seeds to the States. Its commercial seed production centers augment efforts of the States in supplying commercial silkworm seed to farmers.

Table 27: Total quantity of seed production period (2012-13 to 2016-17)

(Unit: Lakh dfls)

Particulars	2012-13	2013-14	2014-15		2015-16		2016-17	
	Achmnt.	Achmnt.	Target	Achmnt.	Target	Achmnt.	Target	Achmnt.
Mulberry	308.48	338.57	350.00	370.16	375.00	410.50	390.00	430.10
Tasar	39.74	38.44	44.11	42.46	47.14	51.62	47.43	48.60
Muga	4.87	5.00	6.07	6.11	7.26	7.45	8.13	6.87
Eri	4.21	3.61	4.10	5.69	4.52	5.75	5.5	4.78
Total	357.30	385.62	404.26	424.42	433.92	475.32	451.06	490.35

India is the Second largest producer of silk in the World. Among the four varieties of silk produced in 2016-17 (P), Mulberry accounts for 70.1% (21,203 MT), Tasar 10.8% (3,259

MT), Eri 18.6% (5,629 MT) and Muga 0.56% (171 MT) of the total raw silk production of 30,263 MT.

Table 28: Production of Sericulture sector

	XI Plan (2011-12)	XII Plan (2012-17)	XII Plan Achievements					
	Achment.	Target	2012-13	2013-14	2014-15	2015-16	2016-17 {Target}	2016-17 (p)
Mulberry Plantation (Lakh/hr.)	1.81	2.40	1.86	2.03	2.20	2.09	2.27	2.21
Raw Silk Production								
Mulberry (Bivoltine)	1,685	5,000	1984	2,559	3870	4,613	5260	5,205
Mulberry (Cross Breed)	16,587	18,000	16731	16,917	17,520	15,865	17,400	15,998
Sub Total (Mulberry)	18,272	231000	18,715	19,476	21,390	20,478	22,660	21,203
VA NVA								
Tasar	1,590	4,562	1729	2,619	2,434	2,819	3,285	3,259
Eri	3,072	4,238	3116	4,237	4,726	5,060	5,835	5,629
Mega	126	200	119	148	158	166	220	171
Sub Total (Vanya)	4,788	9,000	4964	7,004	7,318	8,045	9,340	9,060
GRAND TOTAL	23,060	32,000	23,679	26,480	28,708	28,523	32,000	30,263

State-wise Production of mulberry and vanya silk during 2016-17

During 2016-17 (P), the total raw silk production in the country was 30,263 MT, which is an increase of 6.1% over the production achieved during the last year and around 94.6% of the annual targeted production for the year 2016-17. The mulberry silk production was 3.5% more during 2016-17(P) over the last year. The bi-voltine raw silk production achieved a record production of 5,205 MT during 2016-17(P) by registering 12.8% growth over previous year. Similarly, vanya silk, which includes Tasar, Eri and Muga raw silks, has achieved 12.6% growth during 2016-17(P) over 2015-16. The area under mulberry during 2016-17(P) is up by 6.0 %.

The State-wise production of Raw silk of mulberry and vanya silk during 2012-13, 2013-14, 2014-15, 2015-16 & 2016-17 (P) are given as:

Table 29: State wise production of mulberry and vanya silk during 2012-13 to 2016-17

#	State	2012-13 Achmnt	2013-14 Achmnt	2014-2015		2015-16		2016-17(P)	
				Target	Achmnt	Target	Achmnt	Target	Achmnt
1	Karnataka	8219	8574	8850	9645	10000	9823	11000	9571
2	Andhra Pradesh	6550	6912	6458	6458	5700	5086	5505	5974
3	Telangana			87	101	150	116	150	119
4	Tamil Nadu	1185	1120	1739	1602	1920	1898	2000	1914
5	Kerala	6	4	6	7	9	11	10	9
6	Maharashtra	97	122	378	221	250	274	285	259
7	Uttar Pradesh	157	188	152	236	257	256	280	265
8	Madhya Pradesh	190	195	222	248	215	257	275	97
9	Chhattisgarh	391	391	301	234	253	263	290	360
10	West Bengal	2070	2079	2417	2500	2567	2391	2706	2565
11	Bihar	22	53	74	53	65	67	84	76
12	Jharkhand	1090	2003	2197	1946	2210	2284	2624	2631
13	Odisha	104	53	111	98	120	117	130	125
14	Jammu & Kashmir	145	136	217	138	135	127	170	145
15	Himachal Pradesh	23n	25	40	30	30	32	40	32
16	Uttrakhand	17	22	37	29	30	30	38	31
17	Haryana	0.13	0.13	2	0.3	1	0.6	2	1
18	Punjab	5	4	14	4	1	0.8	5	2
19	Assam & Bodoland	2068	2766	2939	3222	3810	3325	4103	3811
20	Ar. Pradesh	22	15	38	12	40	37	48	45
21	Manipur	418	487	737	516	560	519	503	529
22	Meghalaya	517	644	776	656	835	857	900	927
23	Mizoram	40	44	54	50	65	64	82	76
24	Nagaland	324	606	599	619	715	631	690	678
25	Sikkim	3	0.20	13	8	7	6	16	10
26	Tripura	15	40	43	48	56	52	65	12
Total		23,679	26,480	28,500	28,708	30,000	28,523	32,000	30,263

Sericulture Development in North-Eastern States

North East has the unique distinction of being the only region producing four varieties of silk viz. Mulberry, Oak Tasar, Muga and Eri. Overall NE region contributes 20% of India's total silk production.

Table 30: Production of all varieties of Raw Silk during the year 2016-17 in North Eastern States

Mulberry	333
Tasar	5
Eri	5,578
Muga	171
Total	6,087

North East Region Textile Promotion Scheme (NERTPS) for Sericulture support in North East Region

Under NERTPS, 2 sericulture projects have been approved viz. Integrated Sericulture Development Project (ISDP) and Intensive bi-voltine Sericulture Development Project (IBSDP) covering Mulberry, Eri and Muga sectors in all NE States. The projects aim at holistic development of sericulture in all its spheres from plantation development to production of fabrics with value addition at every stage of production chain. These projects have been approved at a total cost of Rs. 819.19 crore with GoI share of Rs. 690.01 crore for implementation from 2014-15 to 2018-19. The projects are expected to contribute additional production of 2,285 MT raw silk during the project period and 1,100 MT silk per annum after project period involving 33,550 families, which will generate employment to 1,67,700 persons.

2.5 Biology of Non-Mulberry Silkworms; Different Species of Non-Mulberry Silkworms; their Habit and Habitat; Types of Cocoon and Silk Produced by Them; Vanya Silk Conservation and Rural Livelihood; Initiatives From Govt. Of India

1. Tasar Silk

These are reared in the tropical and temperate zones. Four species of the genus *Antherea* (Hubner) are used for commercial production. They are as follows:

Tropical Tasar Silkworm:

A. Mylitta, D (India)

Oak Tasar:

A. Proyli, J. (India)

A. Pernyi, G.M. (China, USSR)

A. Yamamai, (G.M. Japan)

The word “tasar” was derived from Sanskrit literature, and tasar silk was mentioned in 1590 B.C. There are various genera of family saturniidae, to which tasar silkworm belongs, like, *Antheraepernyi* Guerin–Meneville (Chaina, Japan and former U.S.S.R.), *Antheraeyamamai* Guerin–Meneville (Japan), *Antheraea proylei* Jolly (Indian temperate tasar variety) and *A. mylitta* (Indian tropical variety). India is the only country in the world where all four types of commercial silk are produced. This is due to diverse agro-climatic condition of India. Under non-mulberry though tasar, eri and muga varieties of silk are covered but the major production of non-mulberry silk is of tasar next to eri silk. Tasar silkworm belongs to the genus *Antheraea*.

For the development of wild silk industry, host food plants play a crucial role. There is practically no systematic plantation of food plants for rearing non-mulberry silkworms in India. Therefore, the rearing of tasar silkworm depends upon the availability of wild food plants available in the forest.

Recently, Central Silk Board (CSB) has introduced the concept of systematic plantation of food plants for all non-mulberry silkworms to improve the productivity of vanya silk in India (Shetty and Samson, 1998). According to Sathe and Jadhav (2001) tasar silkworm rearing is practiced mainly in the Central and Southern Plateau region in the humid and dense forest area covering Bihar, Madhya Pradesh, Orissa and West Bengal, extending to the fringes of Uttar Pradesh, Andhra Pradesh and Maharashtra. It is estimated that in India, there is 11.168 million hectare of forest having different primary and secondary food plants for wild silkworms, which are being utilized for tasar silkworm rearing.

However, deep interior forests remained unexploited. In India, about 1.40 lakh tribal families have been engaged in tasar silkworm rearing and get benefited socio-economically. It is an excellent example of healthy biological interaction between primary producer (plant) and consumer (silkworm). It forms an integral part of the ideal ecosystem and probably both of them will not survive without each other. In general, tasar silk was found to display lower strength than that of mulberry silk. A drop in strength of mulberry silk fabric following exposure to sunlight was noticed. Among these wild host, arjun tree (*T. arjuna*) is very important plant species grown under agro-forestry plantation system. Present literature suggested that this plant serve as a suitable host for *A. mylitta* at various locations in India.

a. Tropical Tasar (*A. mylitta*)

These are in dense, humid tropical forest of central and southern parts of India. The major cocoon-producing districts are Singhbhum and Santhal Pargana in Bihar, Raigarh and Jagdalpur in Madhya Pradesh; Mayurbhanji and Keonjhar in Orissa; Purulia and Bankura in West Bengal; Bhandra in Maharashtra; Adilabad, Warangal, Karimnagar, Khammam, Mahaboobnagar, Visakapatnam of Andhra Pradesh; Belgaum in Karnataka.

Tasar silkworm is polyphagous. The primary food plants are eight types. Besides, more than two dozens of secondary food plants.

1. *Terminalia tomentosa*, W & A
2. *T. arjuna*, W&A
3. *Shorea robusta*, Roxb
4. *Lagerstroemia parviflora*, Roxb.
5. *L. Speciosa*, Pers.
6. *L. indica*, Linn.
7. *Zizyphus mauritiana*, Lam.
8. *Hardwickia binata* Roxb.

Table 31: State wise tropical tasar raw silk production (MT)

State	Andhra Pradesh	Bihar	Chhattisgarh	Jharkhand	Madhya Pradesh	Maharashtra	Orissa	Uttar Pradesh	West Bengal	Total
2007-08	7.00	13.80	146.00	143.00	30.00	4.00	47.68	4.00	29.00	424.48
2008-09	13.00	16.00	147.00	296.00	30.14	4.28	57.00	4.15	31.23	599.00
2009-10	10.00	27.00	161.00	403.70	74.00	8.00	71.00	6.00	37.00	797.70
2010-11	4.00	30.00	168.00	766.00	58.00	9.00	78.00	9.00	41.00	1163.00
2011-12	1.33	29.37	293.78	1025.24	79.20	12.35	89.70	10.80	43.96	1585.72
2012-13	0.64	7.30	384.87	1088.35	83.00	9.75	95.00	12.30	43.76	1724.97
2013-14	0.46	32.00	384.30	2000.00	86.00	10.20	45.10	13.70	42.20	2614.00
2014-15	0.26	33.00	225.40	1943.30	59.00	19.00	88.30	18.00	43.10	2429.00
2015-16	-	41.00	254.00	2281.00	56.00	21.00	107.00	20.00	34.00	2819.00

b. Oak Tasar

This is a hybrid worm. The oak tract extending from Jammu and Kashmir in the West to Manipur in the east, embracing Himachal Pradesh, Uttar Pradesh, West Bengal, Sikkim, Assam, Arunachal Pradesh, Meghalaya, Mizoram and Nagaland inhabits the temperate tasar silkworm. The food plant is oak plant. There are four species in temperate tasar.

1. *A. proylei*, Jolly
2. *A. roylei*, Moore
3. *A. pernyi*, Guerin-Meneville
4. *A. yamamai*, Guerin-Meneville

The primary food plants are;

1. *Quercusincana*
2. *Q. Serrata*
3. *Q. delabata*
4. *Q. Himalayana*
5. *Q. Semiserrata*

Table 32: State wise oak Tasar Raw Silk Production (MT)

State	Arunachal Pradesh	Manipur	Mizoram	Nagaland	Jammu & Kashmir	Uttarakhand	Total
2007-08	0.03	3.00	0.02	0.16	-	0.50	3.71
2008-09	0.01	3.00	0.10	0.50	0.01	0.50	4.21
2009-10	0.10	3.50	0.20	0.50	0.50	0.50	5.30
2010-11	0.10	2.00	0.40	0.30	0.10	0.10	3.00
2011-12	0.34	2.45	0.93	0.06	-	-	3.78
2012-13	-	2.80	0.72	0.21	-	-	3.73
2013-14	0.02	4.10	0.70	0.29	-	0.06	5.35
2014-15	-	4.17	0.02	0.10	-	0.02	4.31
2015-16	-	4.00	0.10	0.07	-	-	4.08

Life Cycle of Oak Tasar

1. **Egg:** The egg is oval in shape, dorso-ventrally flattened and bilaterally symmetrical along the antero-posterior axis. Eggs of tropical tasar measure about 3 mm in length and 2.5 mm in diameter and weighs approximately 10 mg, while, oak tasar, eggs measure about 2.5 x 2 mm and weighs about 7 mg. Freshly laid eggs are dark brown in colour. After washing, it becomes white, light yellow or creamy. The eggs hatch in around 12 days from the day of hatching.
2. **Larva:** The newly hatched larva is dull brownish yellow with black head, measuring about 7mm long and 1 mm diameter and weighs about 8 mg. The larva at maturity measures about 13 cm long and 2.1 cm diameter and weighs about 50 gm. Various types of tubercles are present on the body. There are several hairs and setae, which are white, minute and irregularly distributed over the body. Shining spots are also present at the base of dorsal tubercles. The tasar silkworms moult four times and pass through five instars. The larval period varies between 30 and 70 days during different seasons in different races. The fully grown larva spins a cocoon taking support of one or two leaves and forming a hammock and a peduncle to firmly cling to the plant. The process takes place in 4-6 days and the shell is very hard.
3. **Pupa:** The pupa is the resting stage in the tasar insects. Pupal period varies greatly lasting from days to months depending upon the voltinism.
4. **Moth:** Females are bigger (4.5 cm) with a broad abdomen and narrow bipectinate antennae of 1.5 cm long. Males are smaller (4.0 cm) with a narrow abdomen and broad antennae. The females are gray or yellow, whereas, males are brown or yellow or gray. Mouthparts are reduced, as moths do not feed. In male, the wingspan is about 16 cm, while, in female, it is about 18 cm. Post-median lines (PM) is red with a white line on the border. The ocellus with a transparent area is prominently positioned at the centre of the wing. Each female moth lays around 200 eggs which continue their generation.

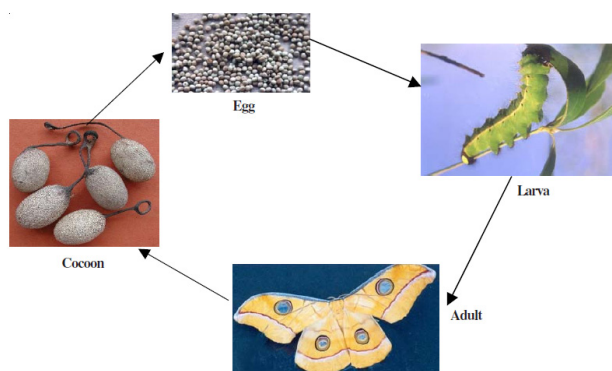


Figure 34: Life cycle of oak Tasar Silkworm

2. Muga Silkworm

The golden yellow silk is secreted by multi-voltine silkworm *A. assamensis*, distributed in Assam. The popular items made from this silk are 'dhoti', 'chaddar', 'chapkan', 'pugree' and 'mekhala'. Assam accounts for more than 95% of the muga silk production. The culture is also spread in different districts neighbouring Assam in Meghalaya, Nagaland, Manipur, Mizoram, Arunachal Pradesh and West Bengal. This silk is very much admired for its durability, lustre and creamy white shade. The muga silk worm is multi-voltine and passes through four moults and five instar stages. Generally 4-5 crops are raised in a year.

Like other Lepidopterans, muga silkworm is a holometabolous insect passing through a complete metamorphosis from egg (Koni) to adult (Chakari) stage through two intermediate stages of larva (Polu) and Pupa (Leta). The entire life cycle lasts for about 50 days in summer and 120 days in winter. The wings and body of the male moth are copper brown to dark brown, while those of female, yellowish to brown. Both pair of wings bears eye spots. Besides colouration, the male moth can be distinguished from the female by its slightly smaller size, slender abdomen, bushy antennae and sharply curved forewing tips. It is a semi-domesticated species in the sense that only the larval stage is spent in open, and the ripening worms are brought indoors for spinning the cocoons.

Life cycle of muga silkworm

Their life cycle is similar to that of mulberry silk insect and completes in about 50 days in summer and 120 days in winter. Like the mulberry silk insect, the muga silk insect also has four stages in the life cycle - egg, larva, pupa and adult.

1. **Egg:** Each female moth lays around 150 eggs. The egg is oval in shape, dorsoventrally flattened, bilaterally symmetrical and creamy to brownish grey in colour and measures 2.3-2.8 mm × 2.4 mm. They hatch in about 7 days in summer and 16 days in winter.
2. **Larva:** The newly hatched larva is black in colour with distinct yellow lines at the inter-segmental region. The body tubercles are yellow and are provided with setae. The head is small but distinct and black in colour. They measure 0.6-1.3 cm in length. They actively feed on the leaves of their food plants and pass through four moults like the mulberry silkworm and reach a size of 4.0 - 5.5 cm in length and weighs approximately 4.10 - 5.15 gm. The dorsal surface of the body is light green while the ventral surface is deeper in colour.
3. **Pupa:** The fully grown larva spins a cocoon around it and then transforms into a pupa. Spinning of cocoon takes 3 to 7 days in different seasons. The pupal stage lasts for 14 days in summer and 40 days in winter. The population in the hills undergoes diapause at the pupal stage to overcome the winter.

4. **Adult:** Moths emerge from the cocoon, mate and lay eggs and continue their generation. Like the mulberry silk moths, they do not have mouth parts and die in about a week.

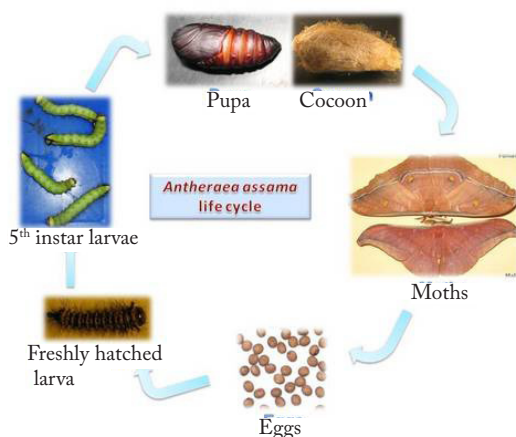


Figure 35: Life cycle of Muga Silkworm

3. Eri Silkworm

The white or brick – red eri silk (endi, errandi) is produced by *Samiacynthiaricini*, - a domesticated multi-voltine silkworm. It is widespread in Assam and also practiced in Bihar, Meghalaya, Nagaland, Mizoram, West Bengal, Manipur, Orissa and Tripura. Among the non-mulberry varieties, eri has the disadvantage of higher production costs because it is made from domesticated silkworms. Among the non-mulberry silkworm species, only eri silkworm is completely domesticated and reared indoor. It is a multi-voltine insect completing six to seven generations in a year. The word 'Eri' is derived from the Sanskrit term "Eranda" which refers to the castor plant and also known as Ahimsa Silk. Eri culture is an age-old tradition and culture of weaker sections of the society particularly in NE India. Eri silkworms require comparatively minimum care as they are easy to handle. India produces 3,116 MT of eri silk during 2012-2013. North-eastern region of India is a homeland of about a dozen of sericigenous insects (Chowdhury, 1982).

Eri silk is widely used for preparing warm clothing like 'Erichadar', quilts and scarves, but other products like kurtas, maxis, dokhans etc. are also available. Eri fabrics warm and more durable than mulberry silk. It is also resistant to perspiration, dust etc. Further, the texture improves by use and wash and the colour also become brighter. Eri culture is believed to have originated in the North-eastern India especially Assam. North – eastern region of India produces more than 90 per cent of eri silk. Assam produces more than 50 per cent of eri silk of the world. Though castor is the main host plant of eri silkworm, but it is mainly annual in nature and has to be grown a fresh every six months. Castor leaf is not available throughout the year.

Life cycle of eri silkworm

The life cycle of Eri silkworm has four stages - egg, larva, pupa (Cocoon) and adult (moth). A complete life cycle lasts about 44 days in summer and 85 days in winter.

1. **Egg:** The eggs are ovoid in shape, candid white in colour, measures 1.5 x 1.0 mm and weighs 6 mg. By the time they hatch, they become ash to blackish colour. They hatch in 9-10 days in summer and 14 - 15 days in winter.
2. **Larva:** The new born larva is greenish yellow in colour measuring about 5 x 1 mm. The fully grown larva measures about 7.0 x 1.5 cm. and weighs 8 g, translucent and covered with a white powdery substance. Different strains have different colours and body marking pattern. The larval span varies from 20 days in summer to 50 days in winter.
3. **Pupa:** Fully mature larva spins a cocoon around it and then transforms into a pupa. Spinning takes around two days and pupation takes another two days. The cocoons are long, soft and without a peduncle. One end is narrow and open. Pupation usually takes around 10-20 days depending on the temperature.
4. **Adult:** The adult moth emerges from the cocoon in about 10 days from the day of spinning. After mating, each moth lays around 400 eggs which depend on the feed and the season. The total life cycle lasts about 45 days in summer and 90 days in winter.

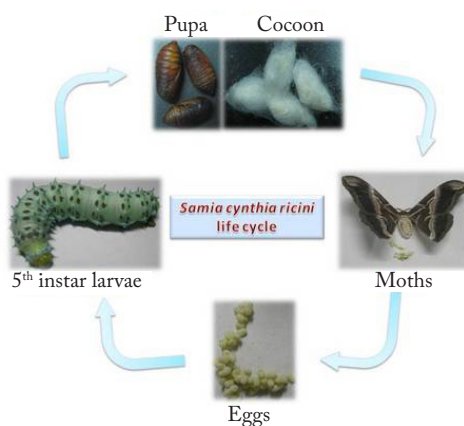


Figure 36: Life cycle of Eri Silkworm

Vanya Silk Conservation and Rural Livelihood

The total forest cover of India as per State of Forest Report 2003 is 678,333 km², which constitutes 20.64 % of the geographic area of the country, plays a significant role in biodiversity protection, global environment conservation, landside prevention and soil preservation, headwater conservation, health, recreational and cultural, material production (silk, timber,

food such as mushroom etc, fertilizers, feeds, raw material for pharmaceutical and other industrial products, extracted ingredients, greening materials etc). These huge forest bio-resources may effectively be utilized for conservation and economic exploration of sericigenous insects available in the country for sustainable rural livelihood and poverty alleviation which is the major issue of developing country including India. It is evident that productivity improvement in mulberry sericulture sector is stagnant in spite of technological intervention in silkworm improvement as well as host plant management. However, growth rate of vanya silk is quite encouraging due to effective utilization of forest cover, improvement of rearing techniques, effective technological support in post-cocoon sectors. The North Eastern states, Jharkhand and Chhattisgarh states of India are primarily dominated by tribal populations. The vanya silks are practiced mostly by these tribal and socio economically disadvantaged sections of the society. Women constitute over 60 % of those employed in downstream activities of sericulture in the country. So, it is a predominantly a women-friendly activity, from rearing to marketing are carried out mostly by women. Even silk reeling and spinning (in case of eri silk activities including weaving is largely supported by them. Every 3.07 kg of silk produced and used in handlooms generates gainful employment of one man year. This potential is par-excellence and no other industry generates this kind of employment, especially in rural areas, hence, sericulture is used as a tool for rural reconstruction. Further, 57 % of the gross value of silk fabrics flows back to the cocoon growers with share of income to different groups (56.8 % to cocoon grower, 6.8% to the reeler, 9.1% to the twister, 10.7% to the weaver and 16.6% to the traders). Thus, large chunk of income goes back to the villages from the cities. Features such as low gestation (20-45 days), high returns make sericulture an ideal programme for weaker sections of the society. Finally, as a perennial crop with good foliage and root-spread, host plants contribute to soil conservation and provide green cover. Waste from silkworm rearing can be recycled as organic manure to garden. Dried twigs and branches are used as fuel in place of firewood and therefore reduce the pressure on vegetation/forest. Further, being a labour intensive and predominantly agro-based activity, it is considered as eco-friendly activity to address the ill-effect of climate changes.

Initiatives from Govt. of India

Central Silk Board, Government of India has branded the vanya silk and symbol is registered as trademark. It depicts a very unique concept of Indian-ness personified by the calligraphic Devanagari letter 'Va' crafted with bold brush strokes inside a cocoon. These symbolize multiple strands of silk. The term "Vanya" is of Sanskrit origin, meaning untamed, wild, or forest based Vanya! – the wild silks of India. The Government of India established the Central Muga and Eri Research & Training Institute, Jorhat under administrative control of Central Silk Board is the only institute for providing research and developmental support for the growth of Muga and Eri industry in the country. Similar institute for Tasar silk has been establishment at Ranchi, Jharkhand state. The deep strides on R & D aspects have

been made in respect of vanya silk conservation and their exploration for socio-economic development of rural masses in the country. To achieve this goal, one exclusive Germplasm Conservation Centre has been developed at Jorhat (India). Further, the centrally sponsored scheme known as Catalytic Development programme (CDP) initiated from IX plan period (1997-2002) onwards to ensure coordinated effort to support sericulture at all stages of value addition, promote new technologies and package of practices, support to efforts of NGOs, Cooperative Societies, Forest Management Committees, Self Help Groups etc. , facilitating linkages amongst stakeholders and strengthening the supply-chain for silk production, improve productivity and reduce input costs, focused largely on supporting stakeholders ranging from food plant to marketing products, creating employment opportunities in rural areas and market orientation to Vanya silks besides public-private partnership in areas of production chain. The Government of India under Forest (Conservation) Act, 1980 has issued notification in respect of vanya silk cultivation. Under this Act, The State/UT Forest Department should encourage silk cultivation in forests areas by tribals and non-tribals who live in and around the forests and are dependent on such forests for their livelihood. However, priority should be given to the tribals and to those enjoy traditional rights on such forests. The State/UT Forests Departments should permit such activities in already identified naturally grown forest areas for silk cultivation and the plantation raised for the purpose thereof in coordination with the State/UT Sericulture Department and Central Silk Board. Cultivation of trees on which vanya silks or silk worms of Tasar, Oak Tasar, Muga and Eri could be reared by tribals and non-tribals living in and around the forest areas for their livelihood without undertaking monoculture plantations should be traded as forestry activity. Therefore, no prior permission of the Central Government under Forests (Conservation) Act, 1980 is required.



Figure 37: Symbol of vanya silk

Research and Development (Highlights on Research Programmes)

1. Vanya Host Plant

- » Identified an alternative food plant *Lagerstroemia speciosa* for Tasar silkworm rearing, which is easy rooter and fast growing. Trials are on to validate the rearing performance.
- » Integrated Nutrient Management (INM) package developed for castor cultivation and it is under field testing.
- » *Ailanthus grandis* (Borpat) has been established as the best perennial host plant for Eri silkworm rearing and recommended for field utilization.

- » Package of practices is recommended for the efficient utilization of Sal flora in Jharkhand and also to improve the Laria productivity on Sal.
- » Biochemical analysis proved similarity in the leaf biochemical of both Castor and *Aliaanthus grandis*.
- » Two Som accessions (S3 & S6) resistant to leaf spot disease, leaf blight and rust are being popularized in the field.

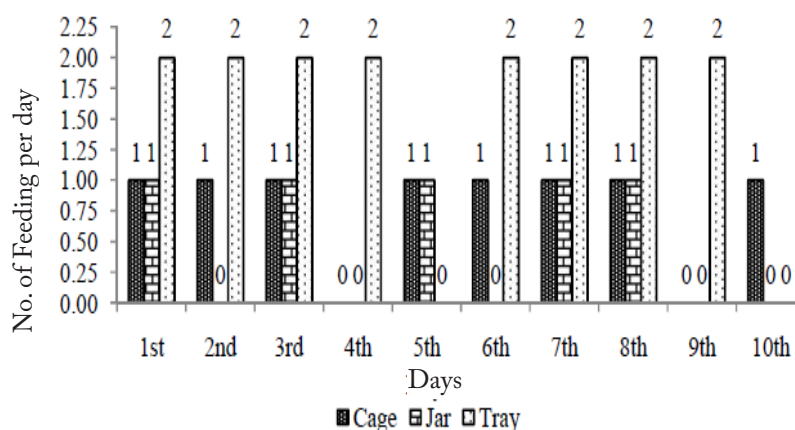
2. Vanya Silkworm

- » Tasar Daba bi-voltine silkworm 'BDR-10' is under popularization and "CTR-14" is under field testing.
- » Eri silkworm breed 'C2' is under popularization.
- » Two superior Muga silkworm lines CMR-1 and CMR-2 are under field testing.
- » Muga silkworm eggs preservation schedule developed to facilitate uniform hatching is under field testing.
- » The in-situ conservation for Muga and other wild silk moth's species is being done under North East Region Textile Promotion Scheme (NERTPS) programme in four states viz. Assam, Meghalaya and Arunachal Pradesh.
- » Developed an organic module against pest and diseases of muga silkworm.
- » Viral & bacterial pathogens associated with flacherie disease in *Antheraea mylitta* D. were isolated and identified.
- » A new chemical disinfectant has been formulated for controlling bacterial flacherie disease in muga ecosystem and testing of the same under laboratory condition is under progress.

The silkworm breeds/hybrids authorized recently for commercial exploitation by the Hybrid Authorization Committee (HAC) are being popularized in the field. Important among them are:

Table 33: New breeds/varieties approved for popularization

New breeds / varieties	Regions
Mulberry Sector	
CSR50 x CSR51	For south zone
(CSR52 x CSR50) X (CSR51 x CSR53)	All India
N x (SK6 x SK7)	
M6DP (C) x SK4	For Eastern Zone
Vanya Sector	
BDR-10 (TASAR)	All regions suitable for tasar culture
C2 (ERI)	All regions suitable for eri culture



Number of feeding given to *Antheraea mylitta* silkworms under Cage, Jar and Tray rearing systems of chawki stage during experimental period

Figure 38: Study on performance of tasar silkworm, *A. mylitta* Drury under different chawki methods

From the above results it could be concluded that tasar silkworm grown under different rearing methods for chawki silkworm stage is influencing on feeding habits and morphological growth of silkworm larva. Tasar silkworm larva grown under Jar method had performed better in respect to food habits and larval growth and development followed by cage rearing method. However, when considering in large scale rearing of chawki silkworm Jar method is question. So, this jar method can be adopted in small scale particularly, experimental purpose. In this large scale situation, cage rearing method for chawki larva can be recommended to farmers who practicing in extensively. Therefore, the cage rearing method of chawki tasar silkworm could be economically feasible, locally available and technically viable.

Table 34: Effects of cocoon parameters reared on primary host plants of muga silkworm, *A. assamensis* W under indoor condition.

Cocoon weight, pupal weight, shell weight, shell ratio, cocoon size of *A. assamensis* reared in indoor and outdoor conditions during jarua (winter season).

Treatment	Cocoon weight (g)	Pupal Weight (g)	Shell weight (g)	Shell ratio (%)	Cocoon size	
					Length(cm)	Breadth(cm)
T1	3.19	2.92	0.23	7.46	3.67	1.73
T2	3.15	2.85	0.22	7.51	3.68	1.76
T3	3.17	2.93	0.23	7.38	3.74	1.72
T4	3.12	2.84	0.22	7.63	3.72	1.70
T5	4.12	3.83	0.33	8.07	4.06	1.96
T6	4.32	3.98	0.35	8.17	4.12	2.05
S.Ed=	0.07	0.07	0.01	0.06	0.023	0.028
CD(5%)	0.15	0.15	0.02	0.13	0.051	0.061
CD(1%)	0.21	0.21	0.03	0.18	0.071	0.086

From the findings, it was observed that the treatments of indoor (T1, T2, T3 and T4) differ significantly from the outdoor rearing (T5 and T6). No significant difference was found in the treatments of indoor rearing. Cocoon weight, pupal weight, shell weight, shell ratio, cocoon size were higher in T6. On the other hand, in the indoor rearing, the cocoon and shell weight was higher in T1 whereas, pupal weight was found highest in T3. It might be concluded that indoor rearing could be done to a very limited extent but would be very difficult for mass scale rearing.

Table 35: Host Plant Relationship in terms of Cocoon Colour and Compactness of Eri Silkworm (*Samia ricini*)

Effect of host plants on cocoon colour of Eri silkworm

Host Plant	Colour (% of respondents)			
	White (A)	Bright White (B)	Creamy White (C)	Dull White (D)
Castor	30	15	47	8
Tapioca	40	10	50	-
Kesseru	20	15	60	5

The colour is a racial character and it is due to the presence of pigments in the sericin layer of the bave. The present investigation revealed that colour was significantly influenced by different food plants. Majority of respondents rated the tapioca fed cocoon as white followed by castor and Kesseru. Similarly tapioca and Kesseru fed cocoons were rated as creamy white followed by castor. Saikia (2008) also observed highest white coloured cocoon on Barkesseru followed by Barpat and castor.

Table 36: Effect of host plants on cocoon compactness of eri silkworm

Host Plant	Compactness (% of respondent)			
	Hard (A)	Moderate (B)	Soft (C)	Very Soft (D)
Castor	10	75	15	-
Tapioca	20	60	20	-
Kesseru	40	45	35	-

It was revealed that host plants had significant effect on the compactness of cocoons. The cocoon spun by the eri silkworm fed on castor leaves were rated as more moderate followed by tapioca and Kesseru. Cocoons obtained from the eri silkworm fed on Kesseru leaves were rated as more hard followed by tapioca and castor. Result of this investigation supported by Saikia (2008) observed highest moderate cocoons on Barkesseru followed by castor and Barpat.

Pests and Diseases of Primary Host Plants of Non-Mulberry Silkworms and their Management

Introduction

Success of silkworm crop depends upon the quality and quantity of leaves per unit area. Non-mulberry silks comprises of Tasar, Oak Tasar, Muga and Eri. Cultures of these silks except Eri are undertaken outdoors. Eri culture is undertaken indoors similar to Mulberry. These worms are wild in nature and fed on the food plants in the existing forests or developed economic plantations. The host plants and silkworm larvae are prone to many diseases and pests. Different diseases are caused due to multiplication and build-up of inoculum of certain foliar, air and soil-borne pathogens. The main factors which influence the occurrence of diseases are the cultivation practices, soil conditions and environmental factors. Temperature, humidity and rainfall also play an important role on spread of host plant diseases in all four types. Feeding of diseased leaves affects the growth and development of silkworm, cocoon yield and silk quality. Hence, keen vigilance and appropriate control measures are essential for protecting the food plants and preventing the spread of diseases and pest attack.

Types of Diseases of Non-Mulberry Silkworm Host Plants

The primary food plants of Tasar silkworm are Sal (*Shorea robusta*), Asan (*Terminalia tomentosa*) and Arjun (*Terminalia arjuna*) and secondary food plants include *Terminalia balerica*, *Terminalia chebula*, *Anogeissus latifolia*, *Lagerstroemia parviflora*, *Buchnanian lanzan* and *Madhuca indica*. The casual organism may be same in different host plants, but its symptoms changes.

Diseases of Tropical Tasar Silkworm Host Plants

1. Black nodal girdling

Causal organism

This is caused by saprophytic and parasitic fungi.

Occurrence

It affects both Arjun (*Terminalia arjuna*) and Asan (*Terminalia tomentosa*) plants during the months of September and October.

Symptoms

Blackening of nectar gland at the leaf base appears first. Later, spreads gradually to whole of the leaf stalk (petiole). Petiole and inter-nodal region soon gets covered with black sooty spores.



Figure 39: Affected plant by Nodal Girdling disease

Damage

Due to nodal girdling, the upper portion of leaves becomes sooty/dirty and dries up affecting the biomass production, in turn reducing the rearing capacity.

Control measures

Prune the affected parts and burn them far away. Spraying of Bavistin (0.2%) at 15 days interval is suggested. Generally, two or three applications are necessary.

2. Powdery mildew

Causal organism

The disease is caused by a fungus called *Phyllactinia terminaliae*.

Occurrence

It is prevalent during winter and rainy seasons with maximum incidence during January.

Symptoms

The symptoms are visible during winter. When seen in sunlight, light greenish patches are visible on the upper leaf surface and white powdery patches appear on the lower surface. They gradually spread to the entire leaf becoming unsafe for silkworm rearing and fall-off prematurely.

Damage

About 8-12 %. Sometimes, it becomes unsafe to feed the infected leaves to the silkworm larvae.



Figure 40: Powdery Mildew

Factors responsible for the spread of disease

The disease is air-borne and it spreads by conidia dispersed through the air currents. Temperature of 24-28°C and high relative humidity (75-80%) are ideal for infection and disease development.

Control measures

Affected leaves should be collected and burnt. Depending on the intensity of infection, 2-3 sprays of 0.05% Dinacop WP (Karathane) or 0.2% Wettable Sulphur (Sulfex) at an interval of 15 days are effective to contain the disease up to 95%. In addition, field sanitation is very important.

3. Leaf curling

Causal organism

The causal organism is yet to be identified. However, this disease appears to be caused due to copper deficiency.

Occurrence

The disease occurs during rainy season.

Damage

Around 15-20 %. Sometimes, rampant occurrence causes great loss up to 90%.

Symptoms

The leaf margins curl inwards. Young leaves show characteristic wrinkling and folding along the midrib forming into a boat-shaped structure. Chlorosis starts from margins and the leaf starts dying / withering.



Figure 41: Leaf Curling

Control measures

Spray of 175 ppm of Copper Sulphate solution on leaves is recommended. Spray of 0.5% of Copper Oxy-chloride is also found effective to control leaf curling. Two to three applications/ sprays are necessary.

Diseases of Oak Tasar Silkworm Host Plants**1. Leaf Blister****Causal organism**

The pathogen causing the disease is *Taphrina caerulescens*.

Occurrence

Common during April-November with peak infection during winter.

Symptoms

Gray depressed areas develop on the lower surface of leaves which look yellow from upper surface. These depressions form blisters.



Figure 42: Leaf Blister

Damage

Leaf quality is reduced.

Control measures

Spray 0.2 % Carbendazim (Bavistin) on young and sprouting leaves twice at 15 days interval. Pick out the dead and diseased twigs/leaves and burn them to prevent the spreading of the disease.

2. Powdery Mildew

Causal organism

The disease is caused by a fungus - *Phyllactinia corylea*.

Occurrence

The disease is common in the autumn season.

Damage

Shedding of leaves prematurely, stunted growth and less foliage production.

Symptoms

Light greenish patches are visible on the upper leaf surface and white powdery patches appear on the lower surface. They gradually spread to the entire leaf becoming unsafe for silkworm rearing and fall-off prematurely.



Figure 43: Leaf Blister

Control measures

Spray fungicides like 0.07% of Tridemorph (Calixin), 0.1– 0.5% of Plantavax or 0.25% of Dithane M-45 (Mancozeb), twice at 15 days interval, one month after pruning is recommended.

3. Sooty Mould

Causal organism

The disease is caused by *Chaectophoma quercifolia*. Sucking pests like Aphids contribute to the spread of this disease.

Occurrence

The disease is common in the winter months.

Damage

Shedding of leaves, stunted growth giving aesthetically unpleasant appearance are the features. The damage caused to leaves reduce the usable biomass.

Symptoms

Lead-black streaks appear on both the upper and lower surfaces of leaves. When the disease advances, the infected area increases and the whole area turns into black powdery coating.

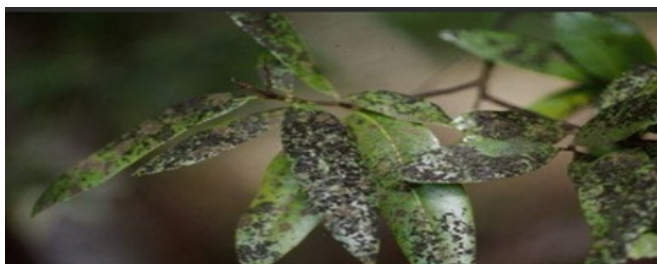


Figure 44: Sooty Mould

Control measures

Application of 0.02 – 0.05% of Dimecron or Dichlorvos, 0.07% Nuvan followed by 0.01% Plantavax spray two to three times as and when the disease manifests to control the sucking pests like aphids.

Diseases of Muga Silkworm Host Plants

Major Diseases of Som Plants

1. Leaf Spot in Som Tree

Casual Organism

The casual organism is *Phyllosticta perseae* Ell. & Mart.

Symptom

- » Circular or irregular brown spots surrounded by yellow margin.
- » Appear on both surfaces of the young and mature leaves.
- » As the disease progresses, the minute spots spread irregularly, become brown in colour.
- » Form larger patches causing the drying up of the entire lamina and results in premature leaf fall.

Control

- » Morphotype S₃ is less susceptible to leaf spot disease.
- » Application of 0.1% Indofil M-45 twice at 15 days interval before the peak season of incidence insignificantly control the disease.
- » Regular cultural operations, pruning and pollarding also prevent the disease.

2. Anthracnose disease in Som tree

The Causal organism is *Colletotrichum gloeosporioides* Penz ..

Symptoms

- » Appears on young and mature leaves in the form of brown colour, round to oval spots.
- » Irregularly spread to the entire leaf.
- » As the disease progresses, the spots got collapsed and malformed.
- » The infected area dries up and become brown to black in colour.
- » At the advanced stage of disease development, brownish colour (stromatic masses or sclerotia) lesions / streaks appears on the twigs also.

- » The top of the branch or the entire branch may wither away.

Control

- » Plucking and burning of infected leaves at the initial stage can minimize the pathogen.
- » Deep hoeing is an effective means to destroy the pathogen inoculum.
- » Timely pruning and utilization of the leaves can prevent the disease.
- » Moreover, destruction of the plant debris checks the secondary infection.
- » Indofil M-45 @ 0.01% can control the leaf blight disease.

3. Grey Blight

Causal Organism

The fungus, *Pestalotopsis dessiminata*.

Occurrence

The disease is common on leaves of Som and Soalu plants. The peak infestation occurs during May-August.

Symptoms

Minute brownish patches appear scattered on the tender leaves here and there. The leaves become dry and turn dark gray in colour from the tip.

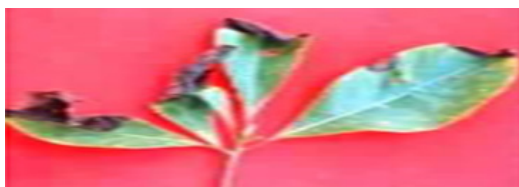


Figure 45: Grey Blight

Damage

Moderate, 15-20% leaf loss occurs.

Control measures

Application of 1 % Bordeaux mixture containing copper sulphate and lime solution 2-3 times

at 15 days intervals when minute brownish patches are noticed. Also, Picking and burning of diseased leaves in early stages of infestation will prevent the spreading of the disease.

4. Red Rust

Causal Organism

The causal organism is *Cephaleurus* sp. belonging to Class Chlorophyceae. It is an inter-cellular algal organism.

Occurrence

The disease is observed throughout the year with its peak incidence during winter months.

Symptoms

Orange patches of about 10 mm diameter appear on the upper surface of the leaf. They are numerous to few, crowded or scattered.

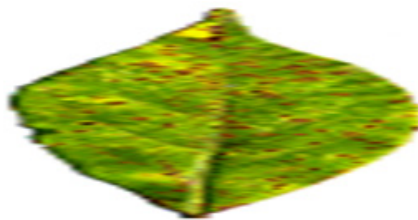


Figure 46: Leaf Spot

Damage

The loss is estimated to be 15-20%. Leaves become yellow and unhealthy. They are not suitable for Muga silkworm feeding.

Control measures

Application of 1% spray of Bordeaux mixture @ 1500 litres per hectare after pruning as and when the disease is noticed for three times at 15 days interval. Clean pruning and removal of the affected twigs and burning them is advisable. Application of optimum dose of potassium fertilizers is also recommended.

Major Diseases of Soalu

1. Red rust in Soalu plant

Cephaleuros parasiticus Karst. is the causal organism of the disease

Symptoms

- » Yellow green, orange or gray colour hairy pustules on the upper surface of the leaves.
- » The pustules are circular or irregular in shape and surrounded by chlorotic halos. Several large rust pustules coalesce to cover a large area of the leaf blade.
- » The affected branches become stunted and bear fewer chlorotic leaves.

Control

- » Pruning and plucking of infected plant parts and leaves help in reducing the disease spread.
- » Timely intercultural operations and utilization of the leaves can prevent the disease.
- » Application of optimum dose of potassic fertilizers also helps in containing the disease.
- » Spraying of 1% Bordeaux mixture is general protective measure.

2. Brown blight in Soalu tree

The Causal organism is *Colletotrichum gloeosporioides* Penz.

Symptoms

- » Appearance of roundish to irregular brown spots on young and mature leaves in the form of 'ash' colour, round to oval spots irregularly spread to the entire leaf.
- » As the disease progresses, the spots, turning to greyish colour.
- » The spots got collapsed and giving a blighted appearance.

Control

- » Plucking and burning of infected leaves at the initial stage can minimize the pathogen.
- » Timely pruning and utilization of the leaves can prevent the disease.
- » "Phyto-blighton" A bio formulation which act as fungitoxic to plant pathogens an

anti fungal bio-product developed by Plant Pathology Laboratory of CMERTI, Lahdoigarh.

Diseases of Eri Silkworm Host Plants

1. Leaf Spot

Causal organism

The causal fungal organism is *Cercospora ricinella*.

Occurrence

It is an air-borne disease common throughout the year. Conidia from fruiting bodies are transferred through the air and are deposited and multiplied on the host.

Symptoms

Black or brown spots with pale green margins develop on both surfaces of leaf. Tiny black dots appear in the white centers.



Figure 47: Leaf Spot

Damage

The black or brown spots make the leaves turn brown and fall-off. Biomass is reduced and the leaves are unsuitable for silkworm rearing.

Control measures

Application of 0.03 % Copper Oxy-chloride, 0.2% Mancozeb, 1% Carbendazim or 5:5:50 Bordeaux mixture two to three times at 15 days interval when the disease is noticed.

2. Fusarium Wilt

Causal organism

The fungus is *Fusarium oxysporum*. It is an important soil and seed-borne disease of castor plant.

Occurrence

The disease occurs throughout the year in castor growing areas, but prominent in February and March at seed formation stage.

Symptoms

Young seedlings at 2-3 leaf stage show discoloration of hypocotyls and lose turgidity. Marginal and inter-venal necrosis of leaves, yellowing and senescence of lower leaves occur leaving few top leaves with irreversible wilting.



Figure 48: Fusarium Wilt

Damage

It is estimated to be 77% loss at flowering stage, 63% loss at 90 days age of the plant and 39% loss at secondary branch stage.

Control measures

Crop rotation for 2-3 years with non-host plants is recommended. Avoid low lying and water logged areas for castor cultivation. Seed treatment with mercuric chloride (Agallol) or Thiram 3 gm per Kg seed is recommended before plantation.

3. Powdery Mildew

Causal organism

The causal fungal organism is a fungus *Leveillula taurica* on Castor plants.

Occurrence

The disease is common during November-March months.

Symptoms

The symptoms are similar to Tasar and Oak Tasar with minor variations.



Figure 49: Powdery Mildew

Control measures

It is suggested to adopt the control measures like spraying of 0.2% Wettable Sulphur (Cosen or Sulfex) twice from the third month of sowing at 15 days interval in dry conditions.

d. Seedling Blight

Causal organism

It is an air-borne disease caused by a fungus *Phytophthora parasitica*, that develops as intercellular mycelium inside the host tissues.

Occurrence

The incidence occurs during monsoon season. The pathogen survives for longer periods in debris and also on other host plants.

Symptoms

Infection occurs both in seedlings and older plants. The affected leaves fall-off prematurely. Young leaves turn yellow and then brown in later stages and fall-off prematurely.



Figure 50: Seedling Blight

Damage

Around 30-40% of damage is caused through drying and rotting of seedlings.

Control measures

Seed treatment with Thiram (3 g / Kg seeds) and spray of Copper Oxy-chloride (3g per litre) once at seedling stage and again at 15 days interval are recommended. Avoid sowing in low lying and ill-drained areas.

Pests of Tasar Silkworm Host Plants

1. Leaf Gall

Causal organism

It is caused by *Trioza fletcheri* minor. Other organisms are *Phylloplecta hirsute*, *Ceroplastes ceriferus* and *Megatriosa hirsute*, which commonly infest both Arjun and Asan plants.

Occurrence

It occurs normally after the sprouting of leaves. If control measures are not taken, the infestation lies as such till the leaves are shed. It is also called as plant tumour.

Symptoms

Tiny green to yellow, round to oval and spherical to flat globules are found irregularly distributed on the leaf surface (Fig. 51) The globules gets enlarged in size (6-7 mm diameter) with the growth of the leaf. When the leaves mature, the globules become hard brown pustules with black dots. The hard dried pustules falloff making the entire leaf full of holes proving the unsuitability of the leaf for silkworm feeding.



Figure 51: Leaf Gall

Damage

The affected leaves are not suitable for rearing. The loss could be 10-20 % in normal infestation while it is as high as 80-90% in severe cases.

Factors responsible for pest attack

Weather conditions like high temperature and high humidity are favourable for the growth of gall insect (Fig. 51).



Figure 52: Gall infested leaf showing pustules

Control measures

Spraying/Application of 0.09% of Dimethoate (Rogor-30 EC) three times at 15 days interval is found to be best preventive measure for the gall infestation with the first spray soon after the new flush of leaf is seen. Picking of egg masses of gall insect and gall infested leaves and burning them is one of the good methods.

2. May-June Beetle

Causal organism

A dark brown to black coloured insect with clubbed antennae and six visible abdominal segments called *Anomala blenchardis*. It measures 1.0 to 1.2 cm in length (Fig. 53)

Occurrence

These beetles are commonly seen in May-June months. They are leaf eating insects, nocturnal in habit. They stay in groups or in isolation in the soil up to the onset of winter nearby the root junctions. The female lays eggs in the soil. Larvae are 2.0 to 2.3 cm long, soft with segmented body. The larvae spend the winter in soil and pupate in spring. The adults appear in May-June and continue till August.

Symptoms

The insects eat away little to larger areas of the medium mature leaves from the margins towards the midrib, sometimes leaving no area for silkworm rearing. These insects eat away the foliage in the nights only.



Figure 53: An infested leaf (left) and a beetle (right)

Damage

The insect larvae or grubs cause damage to the secondary and tertiary roots. The adults cause damage to the foliage (Fig. 53). Extent of crop loss is about 8-10% in general and about 35-40% during heavy infestation.

Control measures

Application of 0.09% of Dimethoate (Rogor-30 EC) three times at 15 days interval with the first spray soon after the new flush of leaf is seen, against the adult insects. Soil application of 2.5 Kg of Phorate or 150 Kg of Neem cake per hectare is also recommended for killing the grubs. Mechanical control is by destroying the bugs, their egg masses and larvae.

3. Stem Borer

Causal organism

The causal organisms are *Sphenoptera koenbierensis*, *Psiloptera fastuosa* and *Aeolesthes holosericea*.

Occurrence

Infestation occurs during February-June. Round headed stem borers, *Aeolesthes holosericea*, are brownish-green coloured elongated larvae living inside the bore hole for about a year to complete its life cycle.

Symptoms

These insects cause tunnels in the stem and bark of the primary Tasar food plants and feeds on the bark and wood inside. The infested branches wither and dry-off and the tree gradually dies. In the bore holes, the developed larvae are generally found.



Figure 54: Stem Borer

Damage

Extent of damage is higher in Asan than Arjun. The loss of biomass ranges from 8-10 % in general to 60-80% during heavy infestation.

Control measures

Small cotton bolls soaked in 0.07% of Monocrotophos-36 EC or 0.05% Phosphomidon-100EC are inserted (plugged) into the holes of the stem twice at 15 days interval with the first plugging soon after the infestation is visible. The round headed stem borer larvae are removed with a spoke rod and destroyed.

Pests of Oak Tasar Silkworm Host Plants

1. Aphids

Causal organism

Three different types of aphids, *Lachnus tropicalis*, *Cervaphis quercus*, *Tuberculatus indicus* infest the Oak Tasar Plants. They are tiny insects with membranous wings and sucking mouth parts. The head is pointed and the abdomen broad and rounded. All the stages of the insect suck the plant sap.

Occurrence

They occur throughout the year, their population is highest during the month of January (28%).

Symptoms

These insects suck plant sap. The insects inject poisonous saliva into plant tissue killing the cells. They often act as disease carriers (vectors). It is interesting that ants which feed on honeydew protect the aphids from their enemies and sometimes provide shelter in their hives during unfavourable conditions (Fig. 55).



Figure 55: Ladybird beetle feeding on Oak Tasar aphids

Damage

Due to injurious saliva injected by the insects in the plant tissue, they often cause deformities in plant parts resulting in reduction of the leaf biomass.

Control measures

Application of 0.09% of Dimethoate (Rogor-30 EC) or 0.05% of Malathion or 0.03% of Dimecron spray twice or thrice at 15 days interval with the first spray during the peak season in January and second spray 15 days before commencement of silkworm rearing is beneficial. Biological control through release of ladybird beetles, *Homonia dimidiata* can also be done (Fig. 55).

2. Hairy Caterpillar

Causal organism

The causal organism is *Phalera assimilis* (Notodontidae: Lepidoptera). Adults are medium sized, about 10 cm across the wings, stout and buff coloured. Adult female lays 200-500 eggs in masses on lower side of leaves. Larvae are orange red in colour. They moult five times during the larval duration of about 40 days. Pupae undergo diapause during winter. The pest completes only one generation per year.

Occurrence

Occurs throughout the year. Severe infestation is observed during the month of July.

Symptoms

It is a major defoliator of Oak plants. Newly hatched larvae start feeding the leaf. Mature larvae devour entire leaf except the leaf stalk.



Figure 56: Hairy Caterpillar

Damage

The damage due to these caterpillars is enormous leaving no biomass for silkworm feeding.

Control measures

Spray 0.05% of Dimethoate (Rogor-30 EC) or 0.05% of Malathion or 0.1% of DDVP (Nuvan) twice at 15 days interval with the first spray 20 days before rearing and the other during the peak period (July). Mechanical control is through destroying of egg masses or larvae.

3. Leaf Roller

Causal organism

The causal organism is *Apoderus notatus*. The adults are small and dark yellow to brown in colour with short and broad brown rostrum with a pair of large mandibles. Head is short, semi-elliptical in shape narrowing posterior to a point and dark yellow in colour. The female lays eggs in the leaf apex that hatch after four days. The small legless, yellowish young grubs feed inside the leaf roll and pupate within two days. The adult bores its way out of the leaf rolls.

Occurrence

The insects are found throughout the year completing two generations in a year, mostly in February-March and July-August.

Symptoms

The leaf roller infests both tender and mature leaves of Oak plants. Both sides of the leaves are cut across the mid-rib near the base and terminal portion and rolled tightly like a cigar.



Figure 57: Leaf Roller

Damage

The damage occurs throughout the year by rolling the leaf for feeding on it as well as for egg laying.

Control measures

Spray 0.04 - 0.05% of Phosphomidon or Dimecron-30EC two to three times at 15 days interval with the first spray 20 days before brushing the silkworm larvae. (To prepare the spray solution, add 0.6 ml of Dimecron or Phosphomidon to one litre of water). Mechanical control is through destroying of egg masses or adults and the leaf rolls.

4. Semi-looper

Causal organism

The causal organism is *Hyblaea puera*. The fully grown larva is about 30 mm long, stout and usually greenish on underside and dark brown or blackish above and walks in loops. There will be 2-3 generations in a year.

Occurrence

These insects occur from February onwards till the rainy season is completed or the onset of winter season. Weather conditions with high temperature and humidity are favourable for these insects.

Symptoms

Defoliation of tender shoots is seen. The young larvae fold leaves together forming an enclosure for protection and start feeding.



Figure 58: Semi-Looper

Damage

Damage of newly sprouted leaves results in reduced foliage.

Control measures

Spray 0.05% of Malathion-50EC or Dimecron two to three times at 15 days interval during peak season and 20 days before rearing silkworms. Mechanical control is through destroying of egg masses or adults and the leaf enclosures.

5. Shoot Borer

Causal organism

The causal organism is *Auletobius densatus*. In Oak Tasar, Shoot Borer is a serious pest. Young short white grubs feed on the pith and then descend to soil to complete their growth by feeding on the fibrous roots. Larvae pupate either in the buds or in the soil.

Occurrence

The adult emerges little before mid-summer, feeds for a short time and hibernates till mid-summer inside the soil. There is only one generation in a year.



Figure 59: Shoot Borer

Control measures

Spray 0.05% of Phosphomidon or Dichlorvos twice at 15 days interval would control

the pest infestation. Soil application of 50 Kg of 5% Aldrin or Chlordane into the soil is recommended to kill the adult insects.

Pests of Muga Silkworm Host Plants

1. Amphutukani

Causal organism

This is a pest of Mango tree. The name Amphutukani is derived from Mango. The causal organism is *Cricula trifenestra* (Saturniidae: Lepidoptera), a polyphagous insect.

Occurrence

The pest is active on Som plants throughout the year in North-East.

Symptoms

Entire leaves are consumed by the worms and the affected plants remain stunted. The tiny worms start feeding gregariously on leaves and in later stages they are solitary in habit.



Figure 60: An infected stem of Som

Damage

During heavy infestation, there is considerable reduction in quantity & quality of leaves.

Control measures

Spray 0.05% of Phosphomidon -100 EC or Rogor spray two to three times at 15 days interval one month before silkworm rearing or as when the infestation is noticed. About 500-900 litres of spray solution is required per hectare. Mechanical control is through destroying of egg masses and caterpillars.

2. Aphids

Causal organism

The causal organism is *Aphis craccivora*. The aphids are minute in size, non-winged, having large eyes and yellowish green abdomen.

Occurrence

They occur during post-monsoon season when the temperature decreases and remain up to April with peak infestation.

Symptoms

The Aphids suck the plant sap from tender leaves, buds and twigs, resulting in rolling of leaf margin followed by curling and wilting of leaves.

Damage

Aphids cause considerable damage to the leaves.

Control measures

Spray 0.4% of Malathion-50 EC or 0.5 % of Dimethoate (Rogor-30 EC) two to three times at 15 days interval coinciding with emergence of new flush. Mechanical control is through destroying of egg and nymph masses and burning the infected parts of the plant.



Figure 61: Aphids in Muga (Nymphs in group)

3. Leaf Galls

Causal organism

Leaf galls are caused by the organism *Peuropsylla besooni*, in Soalu plants and by *Apanteles* sp. in Som plants.

Occurrence

Leaf galls occur throughout the year with a peak infestation from July- October.

Symptoms

Globular or spherical outgrowths formed on upper surface of Soalu and lower surface of Som leaves. The galls on Soalu are oval or globular and that of Som are spherical. The galls are found more towards the tip regions of leaves.



Figure 62: An infected leaf and Leaf galls feeding on Muga host plant aphids

Damage

The gall formation in Soalu is very high than in Som plants with 80-90% loss of foliage during the peak infestation.

Control measures

Spray 0.05% of Dimethoate (Rogor-30 EC) three times at 15 days interval coinciding with emergence of new flush and at early stages of gall formation. Mechanical control is through destroying infested leaves.

4. Stem Borer

Causal organism

Stem Borer called Carpenter Worm is a major pest of Soalu and Som plants besides Tasar and Oak Tasar silkworm host plants. The causal organism is *Zeuzera multistrigata* and *Z. indica*.

Occurrence

Stem borers occur throughout the year with peak infestation during the summer months.

Symptoms

Presence of large sized holes, gummy substance oozing out of the holes and also the faecal matter outside the hole are the symptoms of stem borer attack. The insect attacks mature plants at the base (up to ½ meter from ground level).



Figure 63: Stem Borer

Damage

The larvae make larger tunnels through the trunk and feed on the tissues resulting in retarded growth of the plant. Annually, about 80% of Soalu and 60% of Som trees are affected by this pest. Several cases are reported that the plants die of severe infestation.

Control measures

The holes made by the Stem Borers are plugged with cotton balls soaked in 0.5 % of Monochrotophos or Dichlorvos followed by mud plastering to allow the Stem Borer to die inside the hole.

Pests of Eri Silkworm Host Plants

1. Hairy Caterpillar

Causal organism

The causal organism is *Euproctis lunata*, widely distributed in India.

Occurrence

Infestation occurs during post-monsoon period.

Symptoms

The Hairy Caterpillar feeds on leaves and causes defoliation.



Figure 64: Caterpillars feeding on leaves

Damage

The loss due to defoliation is substantial.

Control measures

Dusting of 5% Aldrin (10 Kg / acre) or spraying of 0.01% of Methyl parathion-50EC or 0.2% of Monocrotophos during October-December.

Two applications are necessary at 15 days interval. Mechanical control is through destroying egg masses and larvae along with damaged leaves.

2. Semi-looper

Causal organism

It is a regular and serious pest on castor. The causal organism is *Achoea janata* (Noctuidae: Lepidoptera). It is also identified as 'Grey looping defoliator'.

Occurrence

Infestation occurs particularly during July to September.

Symptoms

The first stage larvae nibble only the outer tissues of leaves and the second instar larvae make holes into leaves. Later instars devour the leaves.

Damage

Defoliation occurs affecting the plant growth and availability of leaves. About 4-5 semi-loopers per plant can cause more than 25% defoliation.

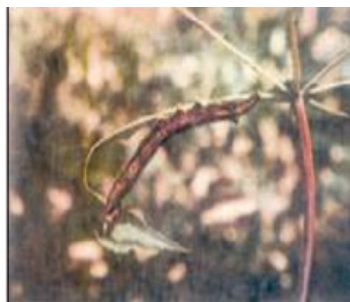


Figure 65: Defoliation caused by semi-looper (left) and a semi-looper on a defoliated branch (right)

Control measures

Spray 600 ml of Daizinon-20 EC or 250 ml of Methyl parathion in 250 litres of water per acre 15-20 days before silkworm rearing will be beneficial. The mechanical control is through destroying of larvae during early stages. Neem Seed Kernel Extract (NSKE) and many neem formulations exhibit strong anti-feedant activity against semi-looper.

3. Thrips

Causal organism

This is a widely spread insect pest. The Causal organism is *Astrothrips parvilibus* and *Retithrips syriacus*.

Occurrence

It is known to act as vector of various viral diseases occurring throughout the year.

Symptoms

Thrips feed on leaves. The infested leaves are damaged which gradually dry and wither away.

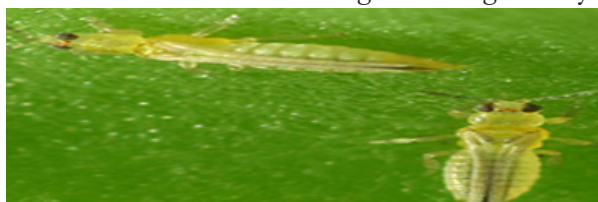


Figure 66: Thrips

Damage

The damage is by laceration of under surface of leaf and sucking of plant sap by nymphs and adults.

Control measures

Spray 0.05% of Methyl parathion – 50 EC or Monocrotophos – 40 EC sprays 4-5 times per year, 15-20 days before taking up the silkworm crop and as soon as the pest appears.

ORGANIZATION AND HISTORY OF CSB, SERICULTURE EXTENSION

3.1 Administrative Set Up in CSB; Role and Responsibilities of State Sericulture Development Department and Schemes

Introduction

The Central Silk Board (CSB) is a Statutory Body, established during 1948, by an Act of Parliament (Act No.LXI of 1948). It functions under the administrative control of the Ministry of Textiles, Government of India, having head quarter at Bangalore. The Board comprises 39 members appointed as per the powers and provisions conferred by Sub-Section 3 of Section 4 of the CSB Act 1948, for a period of 3 years. The Chairperson of the Board to be appointed by the Central Government and two officials to be nominated by the Central Government, one of whom shall be the head of the Silk Division in the Ministry of Textiles as the Vice-Chairperson and one shall be the Secretary of the Board, both being the officers not below the rank of Joint Secretary to the Government. In order to co-ordinate the sericulture development programmes in different states & for undertaking pre-shipment inspection of silk goods meant for exports, the Central Silk Board has established 10 Regional Offices at New Delhi, Mumbai, Kolkata, Jammu, Hyderabad, Chennai, Bhubaneshwar, Guwahati, Lucknow, Patna and 3 Certification Centres at Bangalore, Varanasi & Srinagar. Regional Offices of CSB maintain a close liaison with the State Sericulture Departments, field units and CSB field functionaries to co-ordinate transfer of technology. Regional Offices are also conveners of State Level Sericulture Coordination Committee meetings constituted by the Central Silk Board. The existing staff strength of CSB is 2,994 as on 01.01.2018. The mandated activities

of CSB are Research and Development, maintenance of four tier silkworm seed production network, leadership role in commercial silkworm seed production, standardizing and instilling quality parameters in the various production processes and advising the Government on all matters concerning sericulture and silk industry. These mandated activities of Central Silk Board are being carried out by the 288 units of CSB located in different States through a integrated Central Sector Scheme viz., “Integrated Scheme for development of sericulture Industry” with the following 4 components:

1. Research & Development, Training, Transfer of Technology and I.T. initiatives.
2. Seed Organization.
3. Coordination and Market Development.
4. Quality Certification Systems, Export, Brand Promotion & Technology Up-gradation.

Sericulture Research and Development in Jammu and Kashmir

Role and Responsibilities of State Sericulture Development Department and Schemes

“Kashmir in view of its favorable climatic conditions could be converted into Silkworm gene bank for sustaining the sericulture of the whole world” Dr. Tazima J&K state is known for producing bivoltine silk of international quality. Being one of the traditional agro based industries of the state, producing high quality bivoltine silk comparable to international quality helps in improving the economic condition of the landless farmers and weaker sections of the society and providing employment opportunities during pre and post cocoon activities. Presently about 25500 rural families generating income worth Rs.1100 lakhs annually & 1 lakh mandays in private reeling sector are associated with this profession. With the increased economic needs due to changing social status and unpredictable market trend of different kinds of produces by the farmers of the state, sericulture has assumed special significance as an important subsidiary occupation which supplements the income of the farmers in addition to their returns from the other crops. Basic feature of this farm based economic enterprise is the involvement of women. However production of quality bi-voltine silk is still a challenge in J&K having enormous potential to produce bivoltine silk of international grade, can help to reduce the import of bivoltine silk in the country.

Initiatives taken by the state Govt. for promotion of sericulture in J&K:

1. **Implementation of scheme “Health Insurance for women”** The scheme aims at providing insurance cover to the women engaged in silkworm rearing. It has been introduced in the state for the first time. 5000 and 2500 women rearers were brought under this scheme during 2009-10 and 2010-11 respectively.

2. **Implementation of scheme “Marketing Support to Cocoon Growers”** About an amount of Rs. 32.10 lakhs has been paid to cocoon growers of the state as marketing support on account of low prices fetched by them.
3. **Implementation of scheme “ Cluster Development Programme”** 4 clusters at Tral (Rs.246.575 lakh) and Bandipora (Rs.251.325 Lakh) in Kashmir Division; Nowshera (Rs.238.116 Lakh) and Tikri, Udhampur(Rs. 244.496 lakh) in Jammu Division have been launched in the state to adopt holistic approach for development of sericulture in these areas.
4. **Implementation of scheme “Cluster Plantation”** Concept of Cluster Plantation, both Departmental as well as at Farmers level, has been introduced for the first time in the state, with a minimum of 100 plants to the tune of Rs. 2250/beneficiary per cluster, to augment area under mulberry plantation and during scheme.
5. **Implementation of scheme “Supply of Rearing Kit”** Under catalytic Development Programme 2000 rearers was provided rearing kits at a unit cost of 0.20 lakh and 200 rearers at a unit cost of 0.40 lakh under cluster promotion programme during 2010-11.
6. **Implementation of scheme “Technological advancement scheme”** Hot Air Dryers with capacity of drying 3000Kgs of cocoons in a single shift has been introduced in Jammu. This dryer can also be used for drying other agricultural crops during off seasons.

Role of Temperate Sericulture Research Institute, SKUAST-K

1. **Development of high yielding silkworm genotype:** TSRI (Temperate Sericulture Research Institute) successfully evolved 18 new and productive silkworm genotypes. SKAU-R-1 and SKAU-R-6 & their hybrid SKAU-HR-1 have been notified for commercial exploitation in J & K. SKUAST-28 & SKUAST-30 are at pre release stage. Season specific breeds like SK13xSK31 and SK31xSK6 are in pipe line.
2. **Development of zero energy cost effective poly house technology for quick propagation of mulberry:** The valley in general is not having sufficient mulberry plantation to fulfill feeding requirements of worms up to desired extent. The technology has served as a boon for the industry in the sense that good number of plants can be raised through economic amalgamation of time and cost.
3. **Development of low cost technologies:** Low Cost Rearing Hut designed and fabricated with a view to solve the problem of inadequate space of rearing with farmers has earned wider acclaim. These huts are fabricated out of the locally available material and the investment is very low. One such hut was constructed at the official residence of Hon'ble Minister for Agriculture and Sericulture, Govt of Jammu and

Kashmir in the month of May 2010 and a crop yield of 15.20 Kg (60.80 Kg/ ounce) was harvested on June 23, 2010. Low Cost Solar Cocoon Dryer has been developed by this institute for quick and efficient drying of cocoons for the overall benefit of stakeholders. This dryer is made of iron fitted with an adjustable mirror. Inside temperature raises upto 70°C against 30°C under normal sun drying method. It dries cocoons in 3-4 days as against 7-10 days of sun drying. Capacity of the dryer is 5 kg & lasts at least for 20 years. To improve the returns of farmers practising Sericulture, some value added products viz., Mulberry jam, Syrup, Mulberry tea and Mulberry feed block were developed. Based on the highly satisfactory performance, Mulberry jam & Syrup was marketed by the state Agro Industries Department during 2010 under the name SNOWKIST.

Steps for further development of Sericulture in Jammu and Kashmir

- » Introduction and development of region and season specific silkworm races and mulberry varieties.
- » Increase in area under mulberry cultivation through large scale plantation of improved mulberry cultivars.
- » Promotion of mulberry sericulture enterprise in hilly/border and backward areas. Promote mechanization and rationalization in the field of mulberry cultivation, silkworm rearing and silk reeling to bring down the cost of raw silk.
- » Give sufficient research focus in breeding top obtain suitable bivoltine races.
- » Enhance economic viability of reeling activity through effective utilization of by-products.
- » Apply eco-friendly integrated nutrient/disease and pest management strategies both for mulberry and silkworm.
- » Contribution of women in sericulture development needs to be recognized.
- » Middle level functionaries and technicians should be trained.
- » Massive training to farmers on the basis of result demonstrations, farm field school, printing of literature etc.
- » Study tours/farmer tours to research institutions and advanced sericulture states should be organized regularly.
- » Assistance to seri enterprises/seri graduates to set up sericlinics/seri business centers.

- » Proper and timely marketing facilities.
- » Concentration of efforts on small and marginal farmers.
- » Joint efforts of researchers, extension specialists and farmers to test and modify improved sericulture technologies appropriate for local conditions.
- » Development of sericulture under NREGA.

Schemes of the Central Silk Board

The mandated activities of Central Silk Board are Research and Development, Research Extension, maintenance of four tier silkworm seed production network, leadership role in commercial silkworm seed production, standardizing and instilling quality parameters in the various production processes, promotion of Indian Silk in domestic and international markets and advising the Union Government on all matters concerning sericulture and silk industry. These mandated activities of Central Silk Board are being carried out by the 324 units of CSB located in different States under the following four Central Sector Schemes;

A. Integrated Scheme for development of sericulture Industry

1. Research & development, training, transfer of technology and I.T. initiatives.
2. Seed organization, coordination and market development (HRD).
3. Quality certification systems and export brand promotion & technology up gradation.
4. Catalytic Development Programme (Centrally Sponsored Scheme now restructured as Central Sector Scheme and merged with R&D and Seed schemes).

B. Brand promotion & technology up-gradation

During XII Plan, a new component “Export/Brand Promotion & Technology Upgradation” was conceived and implemented by SMOI & ISEPC. However the scheme Indian silk brand promotion has been implemented only for 2 years for 2013-14 & 2014-15 with interaction with all the stake-holders, exporters, importers, fashion designers etc. This scheme has been discontinued from the year 2015-16 and some of the components of the scheme were merged with the existing Quality Certification System of Central Silk Board for the remaining part of the plan period.

- » Promotional programmes for Indian Silk at Sualkuchi, Uppada and Chanderi have been completed.
- » Developed Exclusive Indian silk portal.

- » Participated in ISC congress by showcasing the products developed at Sandur Kushala Kala Kendra, Bellary district by utilizing the services of renowned visual artist from France Ms. Isabella Arcerio and the tribal women based in Sandur, Bellary District, Karnataka.
- » An exclusive e-commerce portal, www.silkmark.gocoop.com to promote the products of silk clusters has been set up. In the first phase, five clusters namely Varanasi, Bhagalpur, Uppada, Pochampalli and Sualkuchi have been covered. A fairly good response is being received for the portal from the consumers.
- » Two silk Testing Centers have been established at Kolkata and Guwahati catering to the consumers & traders.

C. Centrally Sponsored Schemes (CSS) - Catalytic development programme

Apart from Central Sector Schemes, CSB has also been supporting the State Governments in implementing a Centrally Sponsored Scheme viz. Catalytic Development Programme (CDP) with an aim of synergizing and disseminating improved technology packages, innovations developed by its R & D units and incentivizing investments among the stakeholders to adopt improved technology leading to enhanced production, productivity and improvement in quality of silk so as to enhance the income of primary producers.

During the year 2015-16, based on the recommendations of the 14th Finance Commission, the Govt. of India has increased the State's share in net proceeds of union tax revenue from 32% to 42%. On account of the higher flow of funds to the State Government, the Union Government has taken a decision to windup majority of the Centrally Sponsored Schemes including the Catalytic Development Programme. Accordingly, the Government of India has taken a decision to discontinue implementation of Catalytic Development Programme as Centrally Sponsored Scheme with effect from the year 2015-16. All the above mentioned Central Sector Schemes are organically linked to one another and aimed to increase the quality and productivity of silk in the country thereby enhance the income of Stake Holders. It is therefore brought all these schemes under one Scheme – viz. "Integrated Scheme for Development of Silk Industry".

The CDP Scheme has been discontinued as Centrally Sponsored Scheme, the activities have been taken under Central Sector Scheme viz. R&D and Seed and these two schemes have been restructured to give priority to Breed, Seed, Post Cocoon Technology and Capacity Building. Other two ongoing schemes viz. Coordination and Market Development and Quality Certification System covering SMOI and Brand Promotion will continue without any modifications.

D. Convergence efforts

The Ministry of Textiles is extending support to the sericulture sector in the form of CSS & NERTPS. Efforts are taken for further by mobilizing additional funds through convergence, by availing the schemes being implemented by various other Ministries of Government of India. As per the latest reports received from States, during the year 2014-15, against the proposals of States for Rs. 671.47 crores, the States have received sanction for Rs.256.84 crores, of which Rs.183.14 crore has been released so far under RKVY, MGNREGA and other convergence programmes. During the current financial year 2015- 16 States have submitted proposals for Rs.742.27 crores and received sanction for an amount of Rs.273.76 crores and received funds worth Rs.147.51 crores.

Bivoltine Sericulture Technology Development Project

Central Silk Board in coordination with JICA is implementing a Follow up-Cooperation Programme on JICA projects since 2012. The outcomes of the programmes are:

- » One way multiplication system as recommended by JICA for maintenance of silkworm seed is followed meticulously for quality maintenance.
- » 10 end Automatic Reeling machine has been developed indigenously. The same is under replication to manufacture 40 ends.
- » Rotary Mountages with Nylon net collection system has reduced labour cost up to 50% and found very economical with quality by-cocoon production. The same is under popularization under CSS.

E. North East Region Textile Promotion Scheme (NERTPS Project for Sericulture support for North East Region)

In order to boost the textile sector in the North East region, the Government of India has approved a project- based strategy for the North East Region under an umbrella scheme by name “North East Region Textile Promotion Scheme”. The broad objective of the North East Textile Promotion Scheme is to develop and modernize the textile sector in the North\ East Region by providing the required Government support in terms of raw material, seed banks, machinery, common facility centers, skill development, design and marketing support etc. Under NERTPS various sericulture projects have been approved under two broad categories viz. ISDP and IBSDP.

F. Policy initiatives recently taken for the development of silk industry

Sericulture is the functional area under the Ministry of Textiles. Some of the recent policy initiatives taken by the ministry to promote sericulture are as follows.

- » Sericulture is included as agriculture allied activity under RKVY. This enables the sericulturists to avail the benefits of the scheme for the entire sericulture activities up to reeling.
- » The CSB (Amendment) Act, Rules and Regulations have been notified by the Govt. of India to bring quality standards in silkworm seed production.
- » Forest Conservation Act has been amended to treat non mulberry sericulture as forest based activity enabling the farmers to undertake Vanya silkworm rearing in the natural host plantation in the forests.
- » Increase in basic Custom Duty on silk imports: The Govt. of India during its Budget announcement for 2013-14 has announced increase in the basic custom duty on silk imports from the existing level of 5% to 15% in order to help the silk industry. Earlier during 2011 the Govt. has reduced the custom duty on silk imports from 30% to only 5%, due to which the price of cocoon and raw silk came down drastically. Now the prices have improved and this is seen as a welcome measure for sericulture farmers.
- » CDP-MGMREGA convergence guideline have been finalized and issued jointly by the MOT and MORD. These guidelines will help sericulture farmers to avail assistance from MGNREGA scheme. [Source: Central Silk Board, Ministry of Textiles, Govt. of India, Bengaluru.

Policies of Jammu and Kashmir for Sericulture

Initiative taken by the state Govt. for the promotion of sericulture in Jammu & Kashmir. The Jammu & Kashmir state has taken many new initiatives for promotion of sericulture. Some of the initiatives are enumerated as:

- i. Implementation of scheme 'Health Insurance for women' which aims at providing insurance cover to the women engaged in silkworm rearing. 2500 women rearers were brought under this scheme during 2012 - 13.
- ii. Implementation of scheme 'Marketing support to cocoon growers' Rs. 32.10 lakh has been paid to cocoon growers as marketing support on account of low prices fetched by them.
- iii. Implementation of scheme 'Cluster Development Programme' 25 clusters are operational in the state under holistic approach for development of sericulture in the state.
- iv. Implementation of scheme 'Cluster Plantation' to augment area under mulberry plantation through farmers and on govt. land during the year 2012-13, 11.00 lakh plants (8.00 lakh plants through farmers and 3.00 lakh departmentally) were planted under the scheme 'support for raising of mulberry plantation' and similar no. of mulberry plants are being

planted during financial year 2013-14 with enhanced unit cost of Rs. 5500 / 300 plants.

- v. Implementation of scheme 'Supply of Rearing Kit' under catalytic development programme during the year 2012-13, 2000 silkworm rearers were provided with rearing kit under transfer of technology at a unit cost of Rs, 0.25 lakh under CDP and 1600 more beneficiaries are being covered during year 2013-14.
- vi. Implementation of scheme 'Technological advancement scheme' 20 number hot air dryer at a unit cost of Rs. 1.75 lakh were established in the state to facilitated cocoon drying by farmers on scientific lines by way of shifting the process from the conventional sun drying. This has helped farmers to fetch better prices for their produce.

(A) Support from Central Silk Board (CSB) for development of sericulture

Central Silk Board is providing all support for development of sericulture. With the primary aim of the Institute to boost and revitalized the silk industry of Jammu & Kashmir, CSR & TI, Pampore with its nested units provide need based Research Development / Extension and Human Research Development support to the state and north-west states of the country. The Institute has implemented a number of research programmes, which led to the development of region / season specific technologies resulting in increased productivity levels. Based on the ground realities, the Institute after consulting the active players engaged in Development of Silk Sector developed a 'Model' suitable for development of silk industry. Under bi-voltine production programme, Central Silk Board has established 25 cluster in Jammu & Kashmir. The Institute as a part of national responsibility maintains a rich germplasm of 168 silkworm races and 80 mulberry genotypes of temperate origin for conservation and utilization.

(B) Mulberry sericulture development and extension

- » Landless agriculture labours are being provided with 1 acre of mulberry planted land at Govt. mulberry centers on usufruct right.
- » Rs.6200/- per beneficiary is provided for cultural operation as revolving fund.

(C) Catalytic development programme

- » Beneficiaries under this scheme is provided subsidy for rearing equipment, construction of rearing house, irrigation and for establishment of reeling units.
- » 25% as state share, 25% of share will be borne by beneficiaries and 50% will be borne by CSB respectively.
- » In Few schemes 25% as state share & 50% C.S.B. shares and rest 25% will be borne by beneficiaries.

(D) Tasar sericulture development and extension

- » Beneficiaries under this scheme is provided subsidy for rearing equipment, construction of rearing house, irrigation and for establishment reeling units.
- » 25% as state share, 25% of share will be borne by beneficiaries and 50% will be borne by CSB respectively.
- » In Few schemes 60% as C.S.B. share and 40% will be borne by state and beneficiaries respectively.

(E) Information and technology

- » Website development for online updated information.

(F) Integrated cluster development programme

- » Cluster development would be considered in the far flung areas which are having low socio-economic profile.
- » Taped cluster would be affiliate with sericulture activities by providing facilities as per scheme directives.

(G) Special Project

- » Special Project for the beneficiaries of mulberry, Tasar and sericulture would be prepared under the scheme. The objective is socio economic development.
- » Project will be taken up in partnership with national and international financial institution on the basis of sharing of resources.

(H) Assistance to entrepreneurs/SHGs/NGO's

- » Schemes envisage public private partnership by involving SMEs/SMF/SHG/VOs/ beneficiaries.
- » Emphasis on design development, product development, product diversification and export oriented products.

(I) Promotion and documentation

- » For effective marketability, promotion and documentation.

(J) Sericulture development

- » To develop sericulture in the state, rural areas will be tapped to enhance sericulture activities and beneficiaries.
- » Sericulture employees would be trained by capacity building procurement of seeds on scientific line.

3.2 History of CSB Before and After Independence; Role of Central Silk Board in Research and Development of Sericulture in Different States of India; Sericulture Research in India and its Impact

3.2.1 Introduction and History of CSB Before and After Independence

CSB is an apex body for silk in India and is one of the oldest commodity boards in the country set up as early as in 1948 by an act of parliament. The silk procurement committee that existed during world war 2nd for parachute production was converted into CSB by an act of parliament. Government of India has identified sericulture as one of the cottage industry for the development of rural economy. Besides being an employment oriented industry, it is export oriented too. Realizing the importance of Sericulture, a developing country economy like India, the government of India has constituted the CSB for planned development of silk industry under the stewardship of none other Pandit Jawahar Lal Nehru, the architect of modern India. The CSB is constituted for every 3 years and has 36 members including the chairman and the member secretary, representative of Lok Sabha, Rajya Sabha, the industry and trades, behind the representation of central and state government. CSB has been entrusted with manner to think fit. Legislation in constituent assembly of India establishes that CSB was introduced in 1947. After independence the CSB bill was referred to a select committee in 1948, after submission of report by this committee the CSB bill was passed by a parliament act and it was established. In 1945, the government of India created a Silk Development Directorate and in 1947 organized an all India silk conference. India owes its place in the world silk scenario in this century to the efforts to this apex body constituted soon after independence. It is located in Bangalore. Some of the major functions of board as envisaged in its Act, promoting and developing silk industry by such measures as it thinks fit. Undertaking, assisting and encouraging scientific, technological and economic research in various aspects of sericulture:

1. To create greater opportunities for gainful employment and improved levels of income in sericulture through spread of scientific sericulture practices.
2. To advise the Central government on all matters relating to the development of silk industry including import and export of raw silk.

3. The collection of statistics data improving marketing of raw silk.
4. To improve productivity in all stages of silk production.
5. Strengthen level of efficiency through a commitment to quality makes continuous efforts in research and development and technology development.
6. To prepare and furnish such other reports relating to silk industry as may be required by Central government from time to time.

At the state level, sericultural interests are looked after by respective government. CSB in addition to coordinating activities of various states also allocates amounts to be allocated to each state under 5 year plan. Initially, the board role was pure advisory in nature. In 1958, Sericulture training and research and basic seed production were brought under preview. Later on pre-shipment inspection of silk goods exported from the country as well as import and distribution of raw silk under channelization policy came under its jurisdiction. It has also now taken up several developmental policies to supplement efforts of state government. It has established the international centre for training and research in tropical sericulture in 1980 under a bilateral assistance scheme between India and Switzerland. It has launched the National Sericulture Project 1989-1994 with the celebration of 5 traditional states i.e., Karnataka, Tamil Nadu, Andhra Pradesh, West Bengal, and Jammu and Kashmir aided by World Bank and Swiss development cooperation and this has helped in expanding sericulture to non-traditional states.

Research & development, training, transfer of technology and I.T initiatives

The main Research & Training Institutes of the CSB provide scientific and technological support for enhancing production and productivity for sustainable sericulture through innovative approaches. The main institutes at Mysore (Karnataka) Berhampore (West Bengal) and Pampore (J&K) deal with Mulberry sericulture whereas Ranchi (Jharkhand) deals with Tasar culture and Lahdoigarh, Jorhat (Assam) deals with Muga and Eri culture. Regional Sericulture Research Stations (RSRS/RTRS/RMRS) for Mulberry and Vanya sericulture have been functioning for the development of region specific technology package and dissemination of research findings as per regional needs. Besides, a network of Research Extension Centre (RECs) & its subunits for mulberry and vanya silk are also functioning to provide extension support to sericulturists. In order to provide R&D support in post cocoon sector, the Board has established a Central Silk Technological Research Institute (CSTRI) at Bangalore. In addition, the CSB has also set up Silkworm Seed Technology Laboratory (SSTL) in Bangalore (Karnataka), Central Sericultural Germplasm Resource Centre (CSGRC) at Hosur (Tamil Nadu) and Seri-Biotech Research Laboratory (SBRL) at Bangalore. During the year 2017-18, up to the end of December 2017 a total of 32 new research projects have been initiated and 17 projects have been concluded by various R&D institutes of CSB and currently a total of 150 research projects viz., 92 in Mulberry Sector,

41 in Vanya Sector and 17 in Post cocoon sector are under progress.

Research & development (Highlights of research programmes)

i. R&D on host plant (Mulberry):

- » The third phase of the All India Coordinated Experimental Trials for Mulberry (AICEM) has been completed and the varieties G4 for South, C2038 for East and North regions, and Tr-23 for hilly areas, have been identified for commercial exploitation.
- » Three new mulberry varieties such as AGB-8, PPR-1 and Ganga have been short listed for testing in the next phase of AICEM.
- » Mulberry is found to sequesterate carbon @ 873 kg/ha/yr under moderate tillage in Eastern India and similar studies in Southern India are under progress.
- » Two pheromone compounds were identified for the development of trap for leaf roller. Esterification of identified pheromone compounds revealed the presence of Z-e-7, 11- hexadecenal acetate. Now EAG as well as synthesis of the pheromone compound under progress.
- » “Rot fix” a new formulation was developed against root rot disease with an efficacy of 88-94% disease suppression.
- » The variety C-5 was found superior to the control variety S-1635 C-5 under full dose (17.31 kg/plot) and reduced dose (12.58 Kg/plot) of fertilizer in West Bengal Condition.
- » DNA from 110 progenies was extracted to amplify with primers for Nitrogen Reductase and Chalcone Synthase genes.
- » Leaf yield of Vishala was 12.21% higher i.e 10267 kg/ha/ crop than that of the control (S1635) 9150 kg/ha/crop under irrigated conditions in West Bengal.
- » In order to issue the soil health card, 4388 soil samples were collected and are being analyzed. Identified low temperature stress tolerant mulberry genotypes with high leaf yield viz., C-108 (15.4 mt) C-384 (9.7 mt) and C-212 (9.2 mt).
- » C-2028, a water logged tolerant mulberry variety is being popularized in West Bengal, Assam and other Eastern and North Eastern States.
- » 1291 Mulberry Germplasm accessions are being conserved in the *ex situ* field gene bank.

- » Early vigour, photosynthetic rate, stomatal conductance and transpiration rate of 55 mulberry accessions were studied under ambient temperature and elevated temperature (45°C) and CO₂ (500ppm) to identify superior mulberry genotypes.
- » For effective management of mulberry pests, a mulberry pest incidence calendar for different agro-climates of Eastern and North Eastern regions was developed.
- » Field evaluation of “Nemahari”, a bio-nematicide resulted in the reduction of root knot disease up to 80% with an improved leaf yield (15-18%).
- » Assessing the area under mulberry in major sericulture districts of West Bengal using geo-spatial technique for better management.
- » Identified three putative cold tolerant genes for development of cold tolerant mulberry varieties for temperate regions.
- » Surveyed the incidence of root rot diseases in Kashmir regions and identified the causative organism as *Helicobasidium mompa* and *Fusarium oxiforum*.
- » The data indicated that the maximum mulberry leaf was recorded with spacing (150+90) cm x 60 cm (13174.83 kg/ha/crop) and minimum leaf observed with 270 cm x 60 cm (8842.17 kg/ha/crop). R&D efforts have helped in improving the mulberry productivity from 50 MT/Ha/year during 2005-06 to 60 MT/Ha/year during 2017-18.

ii. R&D on mulberry silkworm:

- » Two new bivoltine hybrids viz., G11 x G19 and B.con1xB.con4 with better yield and adaptation are in the 2nd year of the authorization trials. A total of 5,01,285 dfls of G11 x G19 were distributed to the farmers and the hybrid recorded an average yield of 68.5kg/100 dfls in the southern states against the national average of 58 Kg/100 dfls.
- » Two improved crossbreeds, L3 x S8 and HB4 x S8 tolerant to high temperature and *BmNPV* were developed with a pupation rate of >90%, shell (20-21%) and raw silk (14-15%), further evaluation trials are under progress.
- » Four thermo-tolerant silkworm lines were developed utilizing SSR markers (LFL0329 & LFL1123) associated with thermo-tolerance.
- » Two bivoltine hybrids tolerant to NPV viz., CSR52N x CSR26N, (CSR52N x S8N) x (CSR16N x CSR26N) have been short listed for further testing in the field.
- » Fortnightly surveys were conducted to monitor the disease incidence in seed and commercial rearing areas of South India.

- » 15th generation rearing of 8 lines of Pure Mysore breeds has conducted for qualitative improvement of the breed.
- » New breeding lines (Oval & Dumbbell lines) were raised from Bulgarian and Indian parents and completed F3 generation.
- » Out of 32 hybrids evaluated under artificial inoculation study for disease response to root rot and root knot infections, six hybrids have showed resistance response to both the diseases.
- » Based on the performance, identified two hybrid crosses ICB14 x N23 and ICB17 x S8 with high productivity and improved silk quality.
- » In order to develop high yielding silkworm breeds, five pure breeds and two hybrids were procured from Bulgaria and are being evaluated for further selection and utilization.
- » Multi location trial with NPV resistant transgenic silkworm developed through RNAi technique is under progress in South, east and Northern part of India. Transgenic silkworm showed higher NPV resistance as compared to the control.
- » To develop silkworm hybrids suitable to high temperature and humidity regions of southern India, a total of 35 hybrid combinations were short listed and are being evaluated.
- » Rearing of 25 hybrids of silkworm having high temperature and high humidity tolerance under normal and stress conditions completed to short list the best one for Eastern and North-Eastern India.
- » Authorization trial of B.con1 x B. con 4 with 161500 dfls has been completed and recorded an average cocoon yield of 50.25kg/100 dfls in Eastern India.
- » A new Bivoltine silkworm hybrid Gen-3 x SK6 having cocoon yield potential of 50-55 kg yield/100 dfls, and Multivoltine x Bivoltine silkworm hybrid M6DPC x (SK6 x SK7) with 45-50 kg yield/100 dfls were developed for Eastern region.
- » Breeding for developing hardy silkworm breeds for stabilizing the autumn crop in North and North-Western region is under progress.
- » NPV resistant lines of CSR4 and CSR27 were developed by introgressing the RNAi mechanism from the transgenic silkworm Nistari. These lines of CSR4 and CSR27 showed higher resistance to NPV.
- » Based on the presence or absence of the DNV resistant gene *nsd-2*, three silkworm breeds such as APS-5, APS-HTP5 and BBE198 were identified as DNV resistant.

- » PCR based early detection system for pebrine and NPV has been developed.
- » Field evaluation of the three lines (MASN-4, 6 & 7) of NPV resistant CSR2 silkworm through introgression of NPV resistance has initiated at different agro climatic conditions.
- » Loop-Mediated Isothermal Amplification (LAMP), a simple technique for pebrine detection has been developed and is under validation trial.
- » Identified the suitable breeding resource materials tolerant to high temperature and high humidity conditions and prepared the foundation crosses, further breeding work is under progress.
- » 473 silkworm germplasm stocks (81 Multi-voltine, 369 Bi-voltine and 23 mutants) are being maintained through scheduled rearing.
- » In order to make release of the retaining eggs, use of oviposition stimulants is under progress.
- » Studied the socio economic impact of CPP on bivoltine seri-farmers in Tamil Nadu R&D efforts have helped in improving the yield from 48 Kg/100 dfls during 2005-06 to 60.3 Kg/100 dfls during 2017-18.

iii. R&D on vanya silk:

a. Vanya host plant

- » Identified an alternative food plant *Lagerstroemia speciosa* for Tasar silkworm rearing, which is easy rooter and fast growing. Trials are on to validate the rearing performance.
- » For selecting fast growing drought tolerant *Terminalia arjuna* accessions, 10 superior accessions (Accession No. 102, 115, 123, 135, 424, 507, 523, 525, 614 and 718) selected for further screening.
- » Package developed for moisture conservation and nutrient enrichment of soil in *Terminalia* plantation by incorporating small water catchments at plantation site, wild leguminous plant (*Mucuna bracteata*) and Phosphate Solubilizing Bacteria (PSB). Average increase in leaf yield up to 49.51% using this package.
- » Two Som accessions (S3 & S6) resistant to leaf spot disease, leaf blight and rust are being popularized in the field.
- » Integrated Nutrient Management (INM) package developed for castor cultivation and it is under field testing.

- » *Ailanthus grandis* (Barpat) has been established as potential perennial food plant of Eri silkworm and recommended for field utilization. It recorded leaf yield of 32 MT/ha/yr as compare to Kesseru plants leaf yield of 25 MT /ha/yr.
- » Package of practices is recommended for the efficient utilization of Sal flora in Jharkhand and also to improve the Laria productivity on Sal.
- » Biochemical analysis proved similarity in the leaf biochemical of both Castor and *Alianthus grandis*.
- » Two Som accessions (S3 & S6) resistant to leaf spot disease, leaf blight and rust are being popularized in the field.
- » The *Alternaria ricini* have been isolated in pure form from the infected castor leaves. In bioassay studies antagonistic efficacies of isolate rhizobacteria were tested and isolate LRP-4 and HF-3 showed the maximum inhibition of test pathogen.

b. Vanya silkworm

- » Tasar Daba bivoltine silkworm 'BDR-10' is under popularization.
- » Multi-location field trial for high fecundity Tasar silkworm line, CTR-14 was conducted at five locations. 20-22% gain over control in respect of productive traits was recorded.
- » Two promising lines of Tasar silkworms, DTS and DT-12 selected and 38250 seed cocoons of these lines are under preservation.
- » Eri silkworm breed 'C2' is under popularization.
- » Two superior Muga silkworm lines CMR-1 and CMR-2 are under field testing.
- » Muga silkworm eggs a preservation schedule developed to facilitate uniform hatching is under field testing.
- » Field trial of eri eco race SR-025 at semi-arid conditions of Andhra Pradesh is under progress.
- » Based on characterization, evaluation and categorization of wild sericigenous insects, *Antheraea frithi* has been selected as the future prospective species of the NE region.
- » Six promising strains of eri silkworm viz., YP, YS, YZ, GBP, GBS and GBZ have been isolated from Borduar a Titabar ecoraces based on body marking and color. Two combinations viz. YZ x YS and GBS x GBZ are found promising based on rearing performance. One trial grainage of these combinations completed.

- » The *in-situ* conservation for Muga and other wild silk moth's species is being done under NERTPS programme in four states viz., Assam, Meghalaya, Arunachal Pradesh and BTC.
- » Developed an organic module against pest and diseases of muga silkworm.
- » Characterized phylloplane and gut-bacteria from healthy silkworm.
- » The longest embryonic developmental stage has been detected at the ages of 68 to 72 hr. old embryo which helps in developing suitable egg preservation schedules.
- » Viral & bacterial pathogens associated with flacherie disease in *Antheraea mylitta* D. were isolated & identified.
- » A new chemical disinfectant has been formulated for controlling bacterial flacherie disease in muga ecosystem and bioassay studies of the same under laboratory condition is under progress.
- » Sericin has been separated from tasar silk fibre waste for its isolation and characterization for commercial utilization. The availability of sericin in different fibre waste is about 1.8-2.5%.

New Breeds/Varieties approved for popularization

The following silkworm hybrids are under trial for submitting data to Hybrid Authorization Committee (HAC) for authorization and commercialization.

1. New breeds/varieties of south zone/ region

a. Mulberry sector:

1. G11 x G19
2. MV1 x S8
3. B. con 1 x B. con 4 East and North-East
4. M6DP(C) x (Sk6xSK7)

b. Vanya sector:

1. CTR-14; All regions suitable for tasar culture
2. CMR-1 All regions suitable for muga culture
3. CMR-2

iv. R&D in post cocoon:

- » Development & Demonstration of Indigenous Automatic Silk Reeling Machine (ARM) to produce superior quality import substitute silk.
- » Demonstration of Solar powered low cost spinning machine that can be operated in rural areas by harnessing solar power.
- » Developed the reel boost for improvement in cocoon reeliability and is under laboratory testing.
- » Technologies developed for Hot air drying of Tasar cocoons using conveyor hot air drier.
- » Popularization of Low cost eight end multi-end reeling machine for Tasar silk reeling.
- » In Vanya silk post cocoon sector wet reeling of Tasar and Muga cocoons, Sizing machine for tasar silk, Modified dry reeling machine for tasar cocoons, Pressurized hank degumming machine and Equipment for recycling of silk reeling water are being popularized in field.
- » Demonstration of pellade extraction and pupa separation machine to remove pellade layer from spent silkworm pupae.
- » Developed different varieties of Chanderi sarees (Silk x Silk).
- » Developed technology of “Use of Slug catcher (as replacement for porcelain button) for Slug removing” and is being field tested.
- » Developed technology of “Yarn degumming using CSTRI Eco degumming machine” and is being field tested.
- » Technology for eri cocoon degumming using HTHP extraction (degumming of silk) of sericin from silk yarn in the Hank form developed and recovered sericin from the degumming liquor by low temperature evaporation, spray drying and freeze drying was standardized.
- » Vertical Reeling Machine developed by the Institute has been fine-tuned and made 3 ends machine for higher productivity.
- » Developed Mulberry, Tasar, Muga & Eri silk fabric reinforced with fibroin matrix.
- » Eri silk nonwoven fabrics have been successfully prepared and trials on impregnation with cosmetic formulations for face mask application are under progress at L'ORéal.

- » Characterizing the sericin for its utilization in cosmetics (soaps, shampoos, hair creams, etc and as an additive for talcum powder) applications.
- » Technologies developed for Cooking Raily tasar cocoons for wet reeling.
- » A new tasar cocoon cooking recipe *i.e.*, a combination of Borax and Sodium Bicarbonate developed for Daba, Raily and Modal cocoons were found to be technoeconomically feasible with 67% silk recovery and 33% reelability.
- » A biofinish has been developed, which enhances the properties of Tasar fabrics in terms of aesthetic and thermo-physiological comfort significantly.
- » Developed diversified silk knit wear products/ garments. R&D efforts have helped in improving the Renditta from 8.2 during 2005-06 to 7.3 during 2016-17.

v. Patents and commercialization:

1. During 2016-17

a. Patents obtained:

1. Automatic Tasar cocoon sorting separating machine

b. Applications filed for patenting:

1. Tray washing cum disinfection machine
2. Tasar wet reeling machine
3. Two bobbin wet winding machine
4. Process for enhancing cocoon reelability using Reeliboot
5. Process for the utilization of spent silk moth for producing value added by-products.

c. Technologies/products commercialized:

1. A machine for harvesting silkworm cocoons from plastic collapsible mountages
2. Ankush - an eco-friendly silkworm body and rearing sheet disinfectant
3. Poshan - a multivitamin formulation for correcting the nutrient deficiencies in mulberry.

2. During 2017-18

a. Patents obtained:

1. Chemical formulation for cooking Muga Cocoons for higher silk yield.
2. Improved handloom using pneumatic lifting mechanism for jacquards
3. Improved reeling cum twisting machine

b. Applications filed for patenting:

1. The product 'Rot Fix' has been applied for patenting.

c. Technologies/products commercialized:

1. Pre-steaming technique for improving the winding performance of raw silk skeins

vi. Collaborative research projects and biomaterial research:

1. The R&D institutes of CSB, in addition to the in-house funded projects, are also carrying out collaborative research projects with the financial assistance from DBT, DST, PPV and FRA, Lorel, ILRI Ranchi etc. During 2017-18, a total of 14 research projects with external funding are being carried out.
2. CSB Institutes also collaborate with other research Institutes such as IIT Kharagpur, IARI New Delhi, CCMB Hyderabad, IISc, Bangalore, NIFT Tirupur, Sree Chitra Tirunal Institute for Medical Sciences and Technology, Trivandrum, Kerala, BTRA Mumbai, Coir Board, GKVK Bangalore, ICAR-NBAIR, Bangalore, NEIST Jorhat, TERI Bangalore, NBSS & LUP, Jorhat, BIT Mesra, NCL Pune, etc. At present, 13 such projects are being carried out in collaboration with some of these institutes.
3. International collaboration with different institutes has also been undertaken. Three projects with Deakin University, Australia for developing technology on post cocoon technology and another project aiming at developing DNV resistant silkworm has already been initiated with Japan while another project is being carried out with Bulgaria on breed improvement.
4. MOU has been made with research institutions in Bulgaria, Japan, China, and Australia for exchange of Genetic material to improve hybrid vigor.

Training

The R&D institutions of CSB, spread across the country, covering all activities on the silk value-chain pertaining to all the four silk sub-sectors, are intensively involved in training,

skill seeding and skill enhancement on a sustainable basis. From the year 2015-16 onwards, CSB's capacity building and training initiatives have been restructured under the following five heads to be implemented and monitored by the Capacity Building & Training Division:

- i. **Skill Training & Enterprise Development Programmes (STEP):** Under this category a variety of short-term training modules focusing on Entrepreneurship development, In-house and industry Resource Development, Specialized Overseas Training, popularization of sericulture technologies, lab to land technology demonstration programmes, training impact assessment surveys etc have been planned to be taken up. Some of the popular programmes under this component are: Entrepreneurship Development Programme, Technology Up-gradation Programme, Resource Dev. Programme / Trainers Training Programme, Competency Enhancement Training Programme, Disciplinary Proceedings Training, Management Development Programme etc.
- ii. **Establishment of Sericulture Resource Centre (SRC):** These training cum facilitation centres would be established in select Mulberry bivoltine & Vanya clusters with a unit cost of Rs.3.50 lakhs to act as an important link between Extension Centers of R&D labs and the beneficiaries. The purpose of these SRCs is - technology demonstration, skill enhancement, one-stop shop for Seri-inputs, doubt clarification and problem resolution at cluster level itself. As on date 15 SRCs are functioning.
- iii. **Capacity Building & Training by R&D Institutes of CSB:** In addition to conducting structured long-term training programme (Post Graduate Diploma in Sericulture) the R&D institutes of CSB will also conduct technology-based training both for farmers and other stakeholders besides organizing Krishi Melas, Farmer's day, farmer's interaction workshops etc. for empowering the framers and other industry stakeholders.
- iv. **Capacity Building in Seed Sector:** Silkworm seed is the most critical sector that drives the entire silk value chain. The quality of seed determines the quality of industry output. Therefore addressing the capacity building and training needs of this sector is of paramount importance. It is proposed to conduct a variety of training programmes to cover industry stakeholders like – Pvt. Silkworm Seed Producers, Adopted Seed Rearers, Managers and work force attached to Govt. owned grainages.
- v. **Information, Education and Communication (IEC):** IEC is meant for supporting Capacity Budding and training initiatives by popularizing recommended technologies though Brochures, pamphlets, handouts, booklets etc. This component also propose to produce technology based instructional videos, study materials and documentary films to show case the industry. During September 2017 a total of 1500 copies of Handbook on Silk Industry in India (Info Booklet) have been got printed through publicity.

Role of Sericulture in Rural Development

Rural development is process of improving the quality of life and economic well-being of people living in rural areas, often relatively isolated and sparsely populated areas. The sericulture provides the gainful employment, economic development and improvement in the quality of life to the people in the rural area and therefore it plays an important role in anti-poverty program and prevents migration of rural people to the urban area in search of employment. This industry provides the employment nearly to 3-5 million people in our country. Sericulture is cultivated in Karnataka, West Bengal, Tamil Nadu, Andhra Pradesh, Jammu And Kashmir, Gujarat, Kerala, Maharashtra, Uttar Pradesh, Rajasthan, Bihar, Orissa, etc. It provides employment to approximately 58 Lakh persons, most of them being small and marginal formers or tiny and household industry mainly in hand reeling and hand weaving sections. Thus the sericultural jobs are a source of income. The women participation in sericulture and silk industries are about 60%. By introducing the sericulture industry to larger areas, more women and family members are able to generate substantial income for the family. Many of the studies under taken in China, Thailand and India proved that sericulture industry is an ideal tool for women empowerment and gender equality.

Sericulture Research in India and its Impact

Sericulture plays a vital role in determining the economy of rural population in India. Even if, the contribution of sericulture is not very high but it helped to increase the socio economic conditions of farmers. Consequently any Research and Development programme aimed at the improvement of productivity potential of the sericulture contributes to:

1. The rural employment
2. Socioeconomic development of the farmer without environmental damage
3. The foreign exchange reserves

It can be reckoned that any obstacles in sericultural development can be hazardous to the economy of sericulturists in India. The good news is that technology has helped to overcome many of these obstacles with some very advantageous results. The technologies developed by this Institute have been popularized among the farmers to maximize yield and returns which in turn resulted in bringing out vertical growth of the industry.

The annual mulberry raw silk production has increased to the tune of 23,060 M.T. (2011-12), which includes 18,272 MT mulberry silk, 1,590 MT Tasar silk, 3,072 MT Eri silk and 126 MT Muga silk. The constant efforts made by CSB and state sericulture department have resulted in the overall increase in the silk production and quality.

Scientists working in sericulture Research and Development are constantly putting

their efforts to resolve issues in major areas of sericulture such as silkworm and host plant improvement, pest and disease management, and reduction in cost of production by developing new innovations and technologies and improving the quality of silk fibers to match with international standards. CSB has also been collaborating with both international and national agencies and universities involved in sericultural research, etc., to harness their technical expertise in highly specialized fields and also to pool resources for the development of new technologies in frontier areas of sericulture research.



Figure 67: Scientists working in sericulture research lab

Over the past few decades, the silk industry made good progress with regard to productivity and quality of the output. The productivity of mulberry plantation in terms of silk which used to be less than 40 kg per hectare per year has reached 86 kg per hectare per year besides enhancing India's capability to produce silk of international grades. This could be possible due to evolution of high yielding mulberry varieties such as V1, S1635, S1, S799, S13, S34, S146, BC259 and improved silkworm breeds like CSR2xCSR4, CSR2xCSR5, etc along with appropriate cultivation and rearing practices. The output coupled with the improved processing machinery and practices have made it possible to produce silk of international standards.

3.3 Sericulture Extension: Organization at Various Levels Especially CSB Policy for Development of Research and Training at National and at State Level. Role of Ngos, Self-Help Groups and Private Enterprises in Sericulture Development

Sericulture Extension

Extension is an instrument of change. It is a system of informal education with a focus on farm families and their occupation to promote improvements in farm production, family life and community living. An efficient extension system is therefore essential to achieve the goal of making satisfied improvement in the life of target group. According to Dwarakinath (1994) the extension system is essentially made up of ways of reaching farm families calling their attention to the possible improvement in their pursuits and encouraging them to consider try and adopts those improvements if acceptable. He pointed out the issues affecting the performance of extension system as follows:

1. Extension system works in rural social systems, which is complex in nature. Extension workers have to deal with different social groups, community leaders, local power structure and village institutions.
2. Every Community as its cultural characteristics. Customs traditions norms and value system form not only the heritage of a community but also determinants according to which the individual group and community behaviour are usually regulated. Hence, extension personal must be aware that the individuals are conditioned by culture.
3. Every Community has a communication pattern. One way or other every individual and group in a community are a part in one communication network or the other. Extension workers should make use of such communication patterns in their network.
4. Cultural and technological changes occur in the community all the time with introduction of new innovations. Extension system makes the individuals to adopt the innovations and helps to diffuse in the community. But the community decides the fate of innovation either by adopting it fully or partially or rejecting it.
5. Extension is an informal education process. As extension deals with adult farmers whose learning behaviour is different from the learning behaviour of young persons, it should make suitable adjustments in its educational procedures in order to work appropriately with adults as individuals and groups.
6. In democratic situation, adults participate in extension activities voluntarily. Moreover, farmers are free to accept a recommended practice or not to do so.

All models of extension system consist of five basic components as shown in Figure 68.

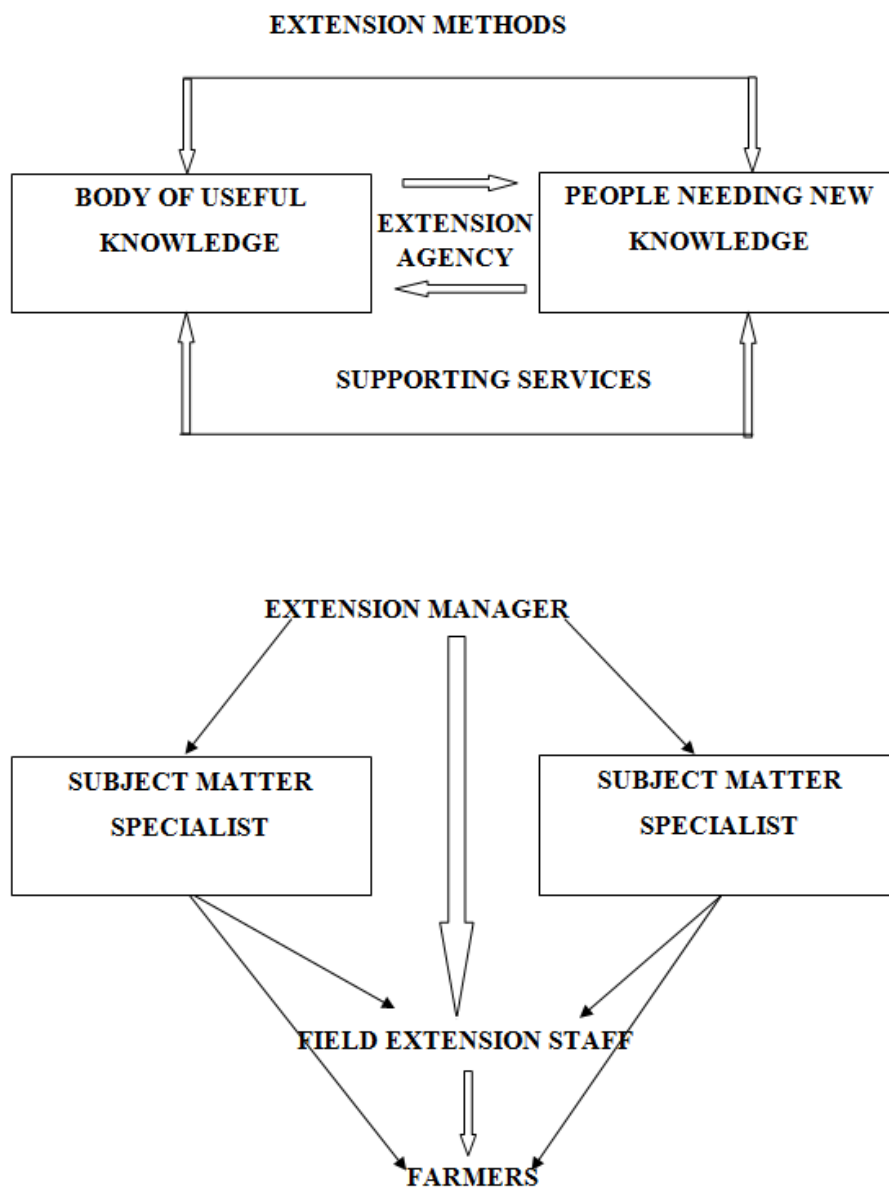


Figure 68: Extension system- Basic Model and A model field extension unit

First, extension service requires body of useful knowledge to extend. Only when there is a useful knowledge, the need of extension arises. The new knowledge is generated by the research system or emanated from resourceful farmers. All the knowledge are collected, organized and validated to become basis form recommended practices n extension. The second component of extension system is people needing new knowledge. Normally, farmers require knowledge to improve their production and income. Extension agency, which is the third important component in the system, is a link between the source of knowledge and users. The task of extension agency is not just transferring the technologies from research institute to farmers but also brings back the problems of the farmers for research investigations.

Another component is the extension methods used by the extension agencies for educating the farmers. The extension agency employs a combination of specialized and established communication channels called extension methods for its purpose. The field extension education workers need to be trained not only principles and practices of extension education but also in selection and effective use of extension teaching methods.

Lastly, the extension system requires support system for the substance of extension work. The basic Endeavour of extension services is to bring improvements in the existing production practices of farmers. The new practices may require use of some new inputs which are often to be purchased from outside. Hence, the extension system should assure the timely supply of adequate inputs to the farmers. Again, the surplus produce should be marketed profitably. Hence, there must be new infrastructure facilities such as input supply agencies, marketing facilities and processing facilities along with technical services in order to sustain the extension work.

Field extension staff must be familiar with local situation, local community, past extension experiences, local leadership and other change agents. The subject matter specialists should have knowledge on local conditions, contact with research agencies, ability to develop extension literatures and train local field extension staff. Further, they should have ability to conduct the field trails and diagnose the field problems. But at present, the subject matter specialists are not functioning in India sericultural extension set-up. Extension manager is the in-charge of the extension team he should have abilities to draw extension programmes according to the local needs and managerial abilities and leadership qualities to lead the team of extension workers.

Major Organizational Streams in Sericultural Extension System

Well-organized extension system is very much essential for pursuing the goal sericulture development systematically. There are three major organizational streams involved in sericultural extension system in India.

These are:

1. Central Silk Board (CSB) through its research institutes and National Silkworm Seed Organization (NSSO).
2. State Government through respective State Sericulture Development (Department of Sericulture) or agencies related to sericulture development.
3. Voluntary Organizations.

Extension Systems of Central Silk Board

At the time independence, like silk industry was scattered and un-organized. Producers were subjected to heavy exploitation. Drastic reduction in requirement of silk following cessation of Second World War coupled with fierce competition from Japan and China affected Indian Sericulture Industry. In this context, the government of India appointed Silk Panel during March 1945 for making recommendations for development of sericulture under a 15 year plan of industrial development for the whole country. This panel recommended for creation of an efficient organization for enunciating and implementing definite policies on all India basis for calculated development of the industry. By accepting the recommendations of Silk Panel, Central Silk Board was constituted in April 1949 under an Act of Parliament (Act No. L XI of 1948). The Central Silk Board is entrusted with the overall responsibility of developing silk industry covering the full gamut of sericultural activities in the country.

At the time of establishment of Central Silk Board, the condition of mulberry sericulture was woeful. Productivity and quality of Indian Silk was inadequate. The cocoon yield was less than 15Kg/100 dfls and the renditta remained at 20. The crop losses were very common and high. The Central Silk Board attempted to adopt temperature technologies on to a predominantly tropical region of India in the 1950s to improve the yield levels. Then it was realized that a tropical oriented research was relevant for the conditions prevailing in India. To meet this requirement, Central Sericultural Research and Training Institute (CSRTI) was established at Mysore in 1962 and the Central Sericultural Research Station, Berhampore established in 1943 was recognized into a full-fledged research institute. Improved technologies were evolved for tropical sericulture and a distinct improvement in yield levels and quality was achieved due to intensive research carried out by these research institutes. The Central Silk Board and the State Government felt that systematic extension was essential to transfer the benefits of research to the farmers in the earlier part of 1970s. Accordingly, CSRTI, Mysore established an extension unit at Lalgondanahalli in Karnataka and CSRTI, Berhampore opened a unit at Malda in West Bengal in 1972. Subsequently, a network of extension centers has been developed by the research unit for transfer of technologies to the field.

Currently, the extension activities are carried out by the research institutes of Central

Silk Board and their attached units namely, Regional Sericultural Research Stations (RSRSs), Research Extension Centers (RESs) and sub units of REC and also by sericulture Service Centers (SSCs) attached to Silkworm Seed Production Centers (SSPCs) under National Silkworm Seed Organization (NSSO).

Extension Activities carried out by the Research Institutes of Central Silk Board

The research institutes conduct research in extension and develop methodology for field extension work. They also educate, train and develop professionals for teaching and research in extension and for the extension service. The field extension work of these institutions is limited to the neighbouring areas. The major extension activities carried out by the research institutes can be listed as follows:

1. Field – testing of technologies evolved in the research laboratory for verification and fine tuning before releasing to the field.
2. Coordination with the state sericulture departments for transfer of proven technologies from research institutes to field and follow-up.
3. Developing a few model farmers in the neighbouring areas to demonstrate the benefits of the adoption of new technologies evolved in the research institutes.
4. Solving the field problems faced by the framers in the neighbouring areas.
5. Conducting extension programmes such as krishi melas, workshops, seminars and radio and television programmes, in which the scientists can directly interact with a large number of farmers.
6. Preparation of audio – visual aids such as manuals, leaflets, booklets, charts, posters and video films in major languages on different sericulture technologies for extension activities.
7. Supplying technologies inputs such as new mulberry varieties, bio fertilizers, chemicals and sericulture farm equipments to the farmers.

Regional Sericultural Research Stations (RSRSs)

The major functions of RSRSs are to conduct region specific research and test-verify the suitability of the technologies evolved by the main research institute to the particular region. In addition, they also perform extension activities in the neighbouring areas. A Joint Director is the in-charge officer for RSRS and 7 to 8 scientists work under him in different levels on mulberry cultivation, silkworm rearing, mulberry and silkworm disease and pet control and extension for conducting research and extension activities. The technical and Field Assistants,

who have required educational qualification, training and experience, assist the scientists. RSRs have farm, rearing facilities, research laboratories and vehicles for conducting research and extension activities. The activities of RSRs can be listed as follows:

1. Test verifying the technologies developed in the main research institute.
2. Conducting applied and time bound problem solving research.
3. Conducting on farm trials and demonstrations with full farmers.
4. Conducting development programmes like mulberry like multiplication of mulberry varieties, silkworm races and diagnostic kits to help the State Government.
5. Conducting training programmes for extension workers of State Governments and farmers.
6. Conducting extension programmes for popularization of improved technologies.
7. Distributing inputs such as silkworm seeds of new races, mulberry cutting and chemicals to the farmers.
8. Conducting surveys on pests and diseases, crop losses and yield assessment.

Research Extension Centers (RECS)

The major role of RECs is to demonstrate the new technologies to the farmers and obtain the feedback about the technologies. They also provide technical guidance and input supply to the sericulture farmers. Two to three scientists work in each REC. field staffs assist them in maintenance of farm and conducting extension activities each REC is covering about 100 – 200 sericulture farmers depending upon the concentration of the farmers in the operational area. The new technologies are demonstrated in the demonstration plots of REC farm as well as with farmers. The major functions of REC are as follows:

1. Conducting demonstrations and popularization of improved technologies and providing feedback to RSRs and main research institute.
2. Conducting training programmes for extension workers and farmers.
3. Conducting extensions programmes such as field days, film shows, group discussions, exhibitions, seminars and study tours for popularization of improved technologies.
4. Distributing inputs such as silkworm seeds of new races, mulberry cuttings and chemicals to the farmers.
5. Conducting surveys on pests and diseases, crop losses and yield assessment.

- » **Sub-Units of REC** - Sub units of REC perform similar functions of REC, but their activities are limited to less number of farmers, Sub-Units of REC are normally headed by a scientist and assisted by field staff at varying levels. Their activities includes demonstration of technologies, providing technical guidance, supply of cuttings and sapling of new mulberry varieties and technical inputs, promotion of new silkworm breeds, conducting extension programmes and surveillance of pests and diseases.
- » **National Silkworm Seed Organization (NSSO)** - The major functions of NSSO are maintenance and multiplication of silkworm breeds in Basic Seed Farms (BSFs) at P3 and P2 levels and production of commercial disease free silkworm layings (DFLs) through Silkworm Seed Production Centres (SSPCs). In addition, Sericulture Service Centres (SSCs) attached to SSPCs carry out transfer of technology activities along with sale of Silkworm seeds. SSCs activities primarily concentrate on sale of DFLs, providing technical guidance to the farmers and distribution of inputs such as mulberry cuttings of high yielding varieties and disinfectant chemicals to the farmers.
- » **Extension Systems of State Governments** - Sericulture being a state subject in the concurrent list, the state Government plays a major role in the development of sericulture. Each of the traditional sericulture states and few other states have established a full-fledged department of sericulture (DOS), which is responsible for whole range of activities that make up sericulture industry. Sericulture development is entrusted to a selected existing organization in the states, in which sericulture development is still in nascent stage.

There are 5 distinct levels in the organizational hierarchy of DOS in Karnataka. Commissioner of Sericulture Development and Director of Sericulture heads the department. The Joint Directors look after the sericulture development activities in the region, which comprises 4-5 districts. The Deputy Director work in district level, Assistant Directors in taluk level and sericulture extension officers at Technical Service Centre (TSC) level. The sericulture extension officers perform the field extension activities with the support of field functionaries working in different levels. The organization structure of DOS in other states varies according to the extent of sericulture development and the organizational policies of State Government.

The DOS performs generally the following functions for sericulture development in the state:

1. Providing technical guidance on sericultural activities
2. Multiplication and supply of high yielding mulberry varieties and silkworm races to the farmers.

3. Maintenance and multiplication of silkworm races at P3, P2 and P1 level and production and supply of disease free silkworm eggs silkworm.
4. Promoting chawki rearing centres for supply of healthy young age silkworm.
5. Providing financial assistance to sericulturists for creating irrigation facilities, mulberry plantation, construction of rearing houses, purchase of rearing equipments and establishment of reeling units.
6. Providing facilities for marketing of cocoons and raw silk.
7. Ensuring reasonable prices for cocoon and silk yarn.
8. Training extension staff and farmers on improved sericulture technologies.
9. Strengthening the research and development in sericulture in the state.

The improved sericulture technologies are carried to the farmers by following individual, group and mass methods of extension communication, folder, manuals, sericulture magazines, posters, video cassettes, radio and television are used to educate the farmers. The facilities created by DOS for the sericulture development in the state are briefly discussed below:

Technical Service Centres (TCSS)

State Sericulture Department have established a number of Technical Service Centres for the purpose of providing supplies, services and technical guidance to arm families practicing sericulture. TSCs usually have a defined jurisdiction in terms of area, villages and number of farmers. Each TSC is headed by a qualified person in sericulture. He is assisted by 4-8 field supervisors with the required educational qualification and experience. The field operatives work at the grass root level with varying educational levels and experience. These field functionaries working in TSCs carry varying designation in different states.

In Karnataka, each TSC is headed by one Sericulture Extension Officer (SEO) and assisted by 4-8 Sericulture Demonstrators at the field level. As per the norms, TSCs cover an area of 200Ha (500 acres) of irrigated mulberry or 1080 Ha (2700 acres) of rainfed mulberry. But in general, the area coverage varies from place to place according to the concentration of sericulturists.

The Major functions of TSCS Include:

1. Providing technical guidance for mulberry cultivation and silkworm rearing.
2. Supplying mulberry cuttings of improved varieties, disease free laying and disinfectants to the farmers.

3. Organizing chawki rearing centres.
4. Implementing various schemes/development programmes of the State Government for the orderly growth of sericulture industry.
5. Providing financial assistance to sericulturists for construction of rearing houses, purchase of rearing equipments and creation of irrigation facilities through financial institutions.
6. Organizing on-farm training on improved sericulture technologies.
7. Conducting extension programmes such as field days, group discussions, exhibitions, film shows, campaigns and study tours.
8. Facilitating the functioning of farmers, groups such as quality clubs and self help group in the villages for better interaction between the farmers on sericulture technologies for continuous improvement in productivity and quality.
9. Monitoring and disease incidences in their jurisdiction taking up timely control measures.

Sericulture training

There are total six Sericulture Training Schools (STSs) functioning in Karnataka, two in Andhra Pradesh and one in Tamil Nadu they provide in-campus training for extension workers and sericulture farmers from different areas. The training programme includes classroom sessions, practical sessions, silkworm rearing by trainees and field visits. The STSs have lodging and boarding facilities. Off-campus training programmes are also organized by TSCs in the farmers' field. This training normally includes lectures, discussions and demonstrations, but mostly without any rearing.

Government Silk Farms (GSF)

DOS has established silk farms to maintain P3 and P2 races. These farms not only help to maintain vigor and multiplication of silkworm races, but also in multiplication and supply of improved mulberry varieties and imparting training to farmers. They also work as demonstration units.

Organization of seed areas

In order to maintain the purity of silkworm seed and check diseases, separate seed areas are earmarked for multivoltine and bivoltine races. In this regard, Karnataka has a systematic seed organization and legislation acts.

Production of commercial silkworm seeds

Silkworm seed is sheet anchor for sericulture industry. Timely supply of adequate quantity of silkworm seed is essential for sustainability of sericulture as a commercial activity. Central Silk Board, DOS and private silkworm seed producers who are popularly called as Licensed Seed Producers (LSPs) are in the venture of commercial production of silkworm seeds. The DOS regulates the activities of LSPs in maintenance of quality, which is essential for success of silkworm crops. Every year, approximately 32 crores of DFLs are produced and distributed in the country.

Promotion of Chawki Rearing Centres (CRCS)

As young age silkworm rearing in CRCs which have required facilities and technical skills, ensure crop stability and increase cocoon yield, the DOS promotes CRVs by organizing the model CRCs and also regulates the activities of private CRCs for ensuring the production of healthy and robust young age silkworms.

Marketing of cocoon and raw silk

The DoS has established cocoon market and silk exchanges in various places to avoid malpractices and exploitation by middlemen in transaction of cocoon and raw silk. These regulated markets are notified and the transactions are carried out through open auction. The Government of Karnataka created Price Stabilization Fund Authority (PSFA) in 1984 to protect the farmers from losses due to any undue fall in cocoon prices. Similarly, Karnataka Silk Marketing Board (KSMB) has been established in Karnataka to buffer the fluctuation in raw silk prices.

Voluntary organizations in sericulture development

Since the voluntary/Non-Government Organizations (NGOs) have the flexibility and people-centered extension style, they play an important role in sericulture development by providing infrastructure facilities and sericulture services to farmers. The NGOs owing to their physical proximity can have more participative approaches with the farmers and take up the responsibility of timely supply of inputs such as planting materials, silkworm seeds and technological inputs since NGOs working in an area generally have a consistent long-term involvement and are well conversant with the existing agricultural practices, they can more effectively integrate sericulture into existing farming system. Also, unlike the bureaucratic government owned extension agencies, NGOs can have holistic activities alongside to facilitate sericulture extension. Considering the comparative advantages of NGOs in sericulture extension, the government also encourages the NGOs in sericulture development in the recent years.

Extension Service in Sericulture

In addition to the regular extension education activities, the State Sericulture Department and Central Silk Board perform a whole range of activities for all round development of sericulture industry. These activities include organization of seed areas, production of disease free silkworm laying, organization of Chawki rearing centres (CRCs), input supply, technical services, facilities for cocoon and raw silk marketing, price stabilization for cocoon and raw silk and in-house research on sericulture. The input supply includes distribution of mulberry cuttings for new plantation, silkworm eggs, disinfectants, rearing equipments and material and arrangement of credit to the farmers. We can briefly see the major extension support provided for sericulture development by State Sericulture Departments and Central Silk Board in the following sections:

Chawki Rearing Centres (CRCS)

Chawki rearing is essential for ensuring successful silkworm crops. Chawki means the first stage of silkworm rearing. If the chawki worms are not reared properly, the later stages will result in crop losses. Hence, chawki is the most crucial period of silkworm rearing that demands optimum temperature and humidity, hygienic conditions, quality tender leaf, good rearing facilities and above all technical skills. Most of the sericulturists in India are devoid of the above facilities. The CRCs are therefore essential to ensure crop stability and increase cocoon yield. The advantages of CRCs as indicated by Kawakami (1999) are as follows:

1. Raising of healthy and robust young age worms, which ensure stabilization of cocoon crop and increase cocoon yield.
2. Producing of cocoon crop and increase cocoon yield.
3. Reducing the chances of contamination and spread of diseases.

Chawki worms are reared in cooperative and /or community shawki rearing centres and distributed to farmers in China and Japan. In India chawki worms are produced by private entrepreneurs and Government owned CRCs. A large number of CRCs were established during World Bank assisted National Sericulture Project (NSP) in various parts of the country. But majority of them were not able to sustain due to various reasons. Currently, establishment of CRSs is strongly advocated for popularization of bivoltine sericulture under Project for Promotion of Popularizing Bivoltine Sericulture Technology (PPPBST) in India (Kawakami, 1999).

The essential requirements for production of healthy and robust chawki worms in CRCs are as follows:

a. Production of quality mulberry leaves

- » Separate mulberry garden with suitable mulberry varieties for chawki rearing.
- » Applying adequate quantity of measures, fertilizers and irrigation.
- » Proper training and pruning of mulberry plants.

b. Use of quality silkworm eggs

- » Care during transpiration of silkworm eggs.
- » Incubation and black boxing of eggs before brushing

c. Conducting pathogen free silkworm rearing:

- » Possessing separate rearing room with required appliances, heating and humidifying equipments are essential for CRCs.
- » Proper disinfection and maintenance of hygiene in chawki rearing for avoiding contamination.

However, wing to various reasons; the CRCs are not popular in India. A study conducted by Kumarsan and Geetha Devi (1997) on performance of CRCs indicated that the CRCs were not able to function properly due to inadequate infrastructure facilities, lack of commercial motivation, high production cost, poor profitability, reduction in mulberry area, credit sales and unethical trade practices followed by the owners of CRCs.

Basic Seed Farms (BSFS)

Production and supply of required quantity of disease free eggs to the farmers on time is one of the prerequisites for achieving sustainable cocoon production. It needs healthy and disease free parent cocoons of authorized races. Hence, systematic and scientific multiplication of seed cocoons at different levels to ensure purity and vigor of the breeds is essential for the production of large quantity of commercial hybrids. The organized set-up comprising maintenance of breeder stocks and its multiplication forms 'seed organization' (Datta *et al.* 1995).

Sound seed organization system exists in the sericulturally advanced countries such as China and Japan. Three-tier multiplication is considered to be more ideal and efficient and followed by Japan (P3, P2 and P1) and China (Great Grand Parent, Grand Parent and Parent). Three –tier system is also followed in India, but operates only in three southern states namely Karnataka, Andhra Pradesh and Tamil Nadu (Datta *et al.* 1995). The number of multiplication cycles generally dependent on the commercial seed requirements. The breeder stock (P4) is maintained by the breeders of research institute and supplied to the

multiplication units on request or as per predetermined programme. P3 and P2 multiplication are conducted in BSFs while P1 seed is reared by the farmers in seed areas and also by the selected farmers of each silkworm seed production centre.

The essential requirements of BSFs for achievement of their objectives are:

1. Good mulberry garden with high yielding mulberry varieties, sufficient spacing and assured irrigation.
2. Separate chawki garden.
3. Separate young age and late age rearing houses with required rearing appliances.
4. Possessing disinfectant machines, incubation facilities, heaters and humidifiers.
5. Separate mounting space.
6. Well –trained technical staff.
7. Knowledge on breed characters.

According to Basavaraja and Suresh Kumar (1998) only 20% of BSFs were functioning true to their objectives. Possession of required facilities for leaf production and silkworm rearing, maintenance of mulberry garden and silkworm rearing as per recommendations and meticulous planning and execution can only strengthen the seed multiplication system on scientific line.

Seed areas

Multiplication of pure races requires more care and better management. The pure aces are more susceptible to diseases compared to hybrids. The yield is also comparatively less in pure races. Any contamination in the parent seed mat affected the seed production, which in turn affected the sericulture industry. For these reasons, the rearers of adjoining villages are grouped together and notified by the Government as seed areas for effective monitoring of seed corps. Seed areas are notified zones by the Government, where large – scale multiplication of parent stocks is conducted through the silkworm rearers (Kariappa and Thangavelu, 1995). The State Legislature in Karnataka has enacted the Karnataka Silkworm Seed Control and Distribution Act, 1982 to regulate the production and supply of silkworm seed and cocoons. The Government subsidized the inputs and ensures attractive prices for seed cocoons so that the earnings from pure race rearing is lucrative.

The Government of Karnataka has clearly demarcated seed areas. Kunigal Taluk and Hebbur Gobli of Tumkur Taluk in Tumkar District and Magadi Taluk of Bangalore Rural District have been earmarked as seed areas for multivoltine race in Karnataka, where the

department of Sericulture has demarcated 902 Villages for the production of Mysore seed cocoon. A total of 4379 Ha of mulberry area is reported to be available and 16400 seed farmers are engaged in the rearing of Pure Mysore breed to produce around 132 crores of seed cocoon in a year. (DOS, Karnataka, 2000). Several small seed zones spreading in 38 taluks in 10 districts have also been identified for bivoltine races in Karnataka apart from regular seed areas of attibelle, Anekal and K R Pet. Fifteen State Government TSCs are functioning in the seed areas for providing technical guidance inut supply and services for seed cocoon growers. Eight cocoon markets have been established in the seed area to ensure the regular flow of seed cocoon to grainages. Similarly, Department of Sericulture, Andhra Pradesh and Tamil Nadu have exclusive seed areas for multivoltine nd bivoltine races in their respective states.

Seed farmers get special incentives to produce better quality cocoons. The quality of seed cocoons are assessed by visual examination of the cocoon, yield per 100dfls, number of cocoons per kg and finally, gut examination for disease free nature. the rejected seed cocoon and excess cocoon are sold for reeling purpose.

Cocoon and raw silk markets

Marketing is the performance of all transactions and services associated with the flow of good form the point of initial production to the ultimate consumers. Thus, the marketing function creates time, place from and possession utilities for the customer desire. In short, marketing is a value adding process for the producer. The development of any industry depends on marketing of its produce. The marketing of the cocoon and raw silk are dealt in detail in Chapter XIX.

Input support system in sericulture

Timely supply of adequate quantity inputs to the farmers should be ensured for practicing sericulture successfully. As a basic supporting system, the well-knitted input distribution network is essential for the development of sericulture industry. A study conducted at CSRTI, Mysore (Jayaram *et al.*, 1996) revealed that the inputs required for sericulture are distributed through Department of Sericulture, private dealers and cooperatives. The participation of the private entrepreneurs in the input distribution was significantly higher than other agencies in the traditional areas, where as the Government agencies played a prominent role in the distribution in the new areas. The inputs distributed through private agencies had different brand names along with different price limits indicating the quality distinction of the inputs.

The inputs namely, credit, disinfectants, manures and fertilizers were found used in sub-optimal levels by the farmers in many studies (Jayaram *et al.*, 1996, Geetha *et al.*, 1997 and Datta, *et al.*, 1999). Bharat Kumar (2000) observed that the flow of credit to

sericulture was not commensurate with the potential identified. As against the ground level credit disbursement target of Rs. 32.62 crores during 1999-2000, the achievement was only 11.32 crores in Karnataka. The major reasons for poor credit off-take were found as weak infrastructure facilities in non-traditional areas, lack of various developmental agencies associated with their sector, inadequate working capital for silk reeling and poor recovery of outstanding sericulture loans. Non-availability of irrigation, credit constraints and high price of fertilizers were the major reasons for not using fertilizers (Kumar *et al.*, 1992). Jayaram *et al.*, (1996) pointed out the major imitations in usage of inputs in sericulture were due to lack of awareness on inputs, improper organization of channels of distribution and reluctance of farmers in accepting the improved practices generated by the research institutes.

Sericulture Extension System in Other Countries

Understanding the extension system of advanced countries in sericulture is quite essential for the students of Sericulture Extension Management to comprehend the subject in full perspective. Hence, the extension system and the current status of sericulture in China and Japan are briefly discussed hereunder:

1. China

China is the homeland for silk and it can be ascertained without any doubt that China is the world leader in silk production and trade. China produced around 64000 tonnes of raw silk during 2000 and controlled nearly 80% of international silk trade. It is estimated that 20 million households practiced seriously by cultivating 2 million hectares of mulberry in 22 provinces out of 25 providences in China. There were 1000 silk factories with 2.4 million ends of reeling machines employing a million workers (Koshy, 2001).

Though sericulture organized in China around 4500 years age, systematic development of sericulture started only after 1920. In China, various specialized organizations involve in the development of silk industry. Pre-cocoon activities are handled by Agricultural Department. Silk industry is managed by Textile Department and exports of silk goods by Department of Foreign Trade.

Chinese extension system is integrated with agricultural extension system unlike in India, where the sericultural extension system is given an independent status. Agricultural Department is in-charge for the production of cocoon, examination of mulberry varieties, silkworm egg production research, education and extension. According to the overall plan for agriculture development, the Ministry of Agriculture formulates policy on cocoon production under long term and annual plans. The local administrations implement the sericulture development plans in coordination with the department's bureau of agriculture of the provinces.

The Sericultural Research Institute (SRI) of the Central Academy of Agricultural Sciences

(CAAS), Zhenjiang in Jiangsu Province is the nodal center for generation and standardization of sericulture technologies. There are 23 provincial research institutes and 12 agricultural universities supporting the nodal research center (Sathyanarayana Raju and Datta, 1997). China's modern sericultural education started with the founding of the Hangzhou Silkworm Institute in Zhenjiang in 1989. Sixteen vocational training colleges deal with sericulture at the intermediate level. Other colleges have departments of silkworm culture, silkworm sections and silkworm training classes (FAO, 1989).

Spreading Centres of Agriculture in the country level provides the technical guidance on sericulture. Full time technicians of sericulture are working in agriculture technology centres in rural areas in major countries. Technical assistant in coordination with peasant technicians provide technical guidance for the farmers. China sericulture association established in 22 Provinces Act as the link between the production units and research and education centres for the academic exchanges. The association conducts periodic conferences, seminars, investigations and on the spot guidance. It is also responsible for editing and printing technical reference materials for the members and departments concerned

The salient features of Chinese sericulture system as listed out by Sathyanarayana Raju and Datta (1997) are here under:

1. Participation of women in sericulture activities is remarkable in silkworm rearing, silk reeling, weaving and fabric making.
2. Participation of peoples' representative in all decision making bodies at all level of management facilities proper presentation of farmers' problems.
3. Disinfection squads are formed by the farmers themselves for mass disinfection. These squads are paid by the beneficiary farmers.
4. The Government encourages group sale of cocoon. Hence, every farmer strives to produce good quality cocoon, the price for cocoons are fixed based on quality.
5. Young age worms are reared in CRCs and distributed to farmers. Direct supply of silkworm eggs to the farmers is not allowed in China.
6. The Government provides subsidy for construction of grainage building and community CRCs.
7. China has region specific mulberry varieties, silkworm races and package of practices.
8. Higher usage of organic manures is encouraged for mulberry garden.
9. The egg supply is made only to CRCs, when have proper infrastructure facilities.

10. The mulberry fields are used to grow vegetables in between the rearing and rearing rooms are used for economically viable activities during the off seasons.
11. Any hazardous factories around mulberry plantations and silkworm rearing houses are banned during the rearing seasons.
12. Uninterrupted power supply is ensured to the incubation centres, even then the residential lines and other places are not having electricity.
13. The sericultural by products are effectively utilized. The income generated from the sericultural by-products and through recycling of natural resources could be higher than the actual income from cocoon sale.

Republic of China adjusts the silk production according to the global demand for silk. It drastically reduced the silk production from the level of 82800 tonnes of silk during 1997 to 64000 tonnes during 2000. Again, the Chinese silk industry is facing with a few problems. The mismanagement in demand and a supply of cocoons due to over expansion of reeling capacity resulted in shortage of cocoon supply and raise in prices for cocoons. Further, the disorderly trading on the export market for silk garments has resulted in fierce competition at ever-dwindling process (Koshy, 2001). The Government has been taking steps to restructure and reorganize the silk industry to strengthen up the Chinese silk establishments in overseas and to stabilize the world silk markets.

2. Japan

Though the silk was originated from china, it was Japan, which developed silk technology for centuries as the world's second largest silk producer. The silk production was in peak in the late 1960s averaging around 20000 tons per annum, but declined afterwards and reached a low level of 391 tons during 2002. The reason for decline in the silk production was due to rapid industrial development in the country, which led to diversion of land away from sericulture and high cost of production of raw silk due to increase in input costs. The domestic raw silk costs three times of import prices making the sericulture industry unviable (Koshi, 2001).

Extension service is a cooperative work of the Ministry of Agriculture, Forestry and Fisheries of National Government and Prefectural Governments. The purpose of the service is to provide support for farmers so that they can improve farming or their standard of living by themselves thereby contributing to the development of agriculture. In Japan, extension system is very extensively developed. There is no separate extension network for development of sericulture. Sericulture, agriculture, horticulture, livestock management and pisciculture together come under the control of Agriculture Extension Cent. The staff of Agricultural Extension Centre looks after the extension work of all the crops. There is strong linkage between national, prefectural and other associations involved in extension network

(Mallikarjuna, 2000). Various organizations functioning in the sericulture extension system are as under:

1. **Ministry of agriculture, forestry and fisheries:** It is the apex body in planning, management and guidance in organizing the activities of extension and development of sericulture and other agro-based activities. Agriculture Production Bureau is mainly responsible for the activities related to the production of paddy, upland field crops such as wheat and soya beans, fruits, flowering plants, vegetables and mulberry cocoons. One of the most important duties is to develop the most profitable crop mix for the farmers. In addition, the bureau undertakes administrative work related to the promotion of mechanization in agriculture and plant quarantine for export and import. It is also involved in cooperation with Prefectural Governments in extension activities, motivation and encouragement of young people to take up agriculture and allied activities. Sericulture being one of the farm-based activities comes under the Upland Corp Division of Agriculture Production Bureau.
2. **Regional office of the ministry of agriculture, forestry and fisheries:** The Regional Offices provide guidance in management of agriculture improvement and extension work in the region. The country is divided into 7 regions and the regional offices look after the promotion of agriculture in the concerned region. The regional offices have liaison with National and Prefectural Agricultural Experiment Stations and provide guidance to the Agriculture Section in the Prefectural Offices.
3. **Government of the tokyo metropolis and prefectures (local governments):** The local governments formulate basic policies for carrying out agriculture development and extension work and decide management strategies for their respective prefectures. The prefectural offices work in liaison with the regional offices in development of agriculture in their prefectures.
4. **Agricultural experiment stations:** National Government, Prefectural Government and local Governments are involved in conducting the research. National Government Research Institute conducts research in basic as well as on the issues of national importance. The agricultural Experiment Stations of prefectural and local Governments are involved in conducting the research. National Government Research Institute conducts research in basic as well as on the issues of national importance. The Agricultural Experiment Stations of prefectural and local Governments conduct research on region and local specific problems. Technologies evolved by the prefectural Government are passed on to the subject matter specialists located in the prefectural agricultural experimental station and then passed on to japanese agricultural association and agricultural extension centre. Though different organizations are involved in research, there is linkage and exchange of information between the organizations.

5. **Subject matter specialists:** In Japan, 655 subject Matter Specialists are working in prefectural level (Bhoghesa, 1998). They are graduates of agriculture or similar ones of universities and have experience in research, training, education and extension activities for at least for 10 years. They should pass the qualification test conducted by the Ministry of Agriculture, Forestry and Fisheries to qualify as Subject Matter Specialist. Subject Matter Specialists normally work in Agriculture Experiment Stations or Bureau of Agricultural Administration of the prefectural Extension centres and also field and provide technical advice and conduct different extension methodologies to improve the activities of Extension Advisors in the farmers' field. They also conduct demonstrations and experiments in the farmers' field to identify and solve the technical and managerial problems occurring in the field. They conduct field survey also for collecting information for their research.
6. **Training in sericulture:** Training is an integral part of Japanese extension system. Four National Farmers Academy and forty-one Prefectural Farmers Academy have been established both in national and prefectural level for imparting training and education to the farmers. There are three departments in the academy as follows:
 1. The foresting department conducts training for young farmers who are expected to support for future agriculture in Japan. This training is conducted for two years in agriculture and technical management for senior high school graduates.
 2. The research department gives advanced training to graduates of foresting department, Subject Matter Specialists and Extension Advisor. Advanced techniques and managerial control ability through project are imparted in this training programme for two years.
 3. The training department organizes short-term training for young farmers, who are engaged in agriculture.
 4. Different training programmes are also conducted or Subject Matter Specialists and Extension Advisors in a planned and systematic manner to make them to cope up with the trends of agricultural and rural areas.
7. **Agricultural extension centres:** Formulate sericulture improvement and extension projects and execute them. The details of extension activities are as follows:
 1. Introducing innovative techniques and comprehensive technologies as per the regional requirements by establishing demonstration farms, holding lectures and publishing magazines.
 2. Recommending suitable crop for the area based on soil diagnosis and meteorological data.

3. Assisting the farmers in processing and marketing of agricultural products by utilizing cooperative societies.
 4. Guiding the farmers in keeping the farm accounts and analyzing for improvement of working condition.
 5. Assisting the farmers in availing loan for purchase of land and machineries and for proper utilization loan.
 6. Helping women to display their decision making abilities in agriculture management.
 7. Helping farmers to utilize personal computer for their management.
8. **Agricultural farmers' cooperatives:** The functions of cooperatives include cooperative use of facilities, joint marketing of cocoons mediation in procurement of agricultural inputs, technical guidance to farmers and liaison with local administration. Cooperative societies arrange marketing facilities for cocoons. The farmers can sell cocoons in any market. The government is providing various kinds of subsidies to the farmers for promoting sericulture.
9. **Japan Agricultural Association (JAA):** JAA is playing a vital role in transfer of technologies. The linkage between Agriculture Extension Centre and JAA and then with farmers is stronger than the linkage between Agricultural Extension Centre and farmers. JAA gets the required technical information from the Agricultural Extension Centre at the regional level and takes appropriate measures to transfer the technologies to the farmers.

The salient features in the extension system for sericulture in Japan as listed out by Mallikarjuna (2000) are as follows:

- i. **Database management:** The Planning, co-ordination and Management Division of the Prefectural Agricultural Experimental Stations maintained the relevant information, data and package of practices developed for different crops in the computer. The interested farmers can directly access the information through internet. The farmers can meet the officials in person or can get information through mail or personal call for any clarification on the information. Such storing of data in the computer helps the farmers to effective decisions on agriculture crop management.
- ii. **Extension communication:** The research stations and Agricultural Extension Centres develop simple extension communication materials like pictorial pamphlets and manuals for making the farmers to understand the new technologies. Standard

reading charts are prepared and supplied to the extension staff and farmers. In addition, other extension education methods such as demonstration, group discussion and field visit are conducted for effective transfer of technologies.

- iii. **Price fixation:** As the prices for cocoon are fixed based on the quality, the farmers are motivated to produce quality product.
- iv. **Crop insurance:** Mutual Assistance Association is an organization created for crop insurance in Japan. In this system, farmer has to pay a monthly contribution towards the mutual fund. If the farmer loses the crop, farmer can get the compensation from the association. The compensation is to an extent of 80%.

Through the silk production has declined drastically in the recent past in Japan, still Japan maintains the leader in the productivity and quality in the silk production by adoption of modern technologies in cocoon and raw silk production.

3.4 Sericulture for Women: Women's Empowerment in Sericulture, Mulberry Garden and Rearing Management, Silk Reeling, Weaving and Finishing

Schemes for Women's in Sericulture

Introduction

Globally, Asia is regarded as the main producer of silk as it produces over 95 % of the total global output. The bulk of it is produced in China, India, Japan, Brazil and Korea. India has been ranked as the second major and largest raw silk producer in the world as it contributes about 18% to the total world raw silk production, with an annual silk production of around 20,000 Metric Tons. Sericulture and Silk Textiles Industry is one of the major sub-sectors comprising the textiles sector. Sericulture is an agro-based labour intensive industry and refers to the mass-scale rearing of silk producing organisms in order to obtain silk. The production process consists of a long chain of interdependent and specialized operations. The major activities involved in a sericulture industry are:

- » Cultivation of silkworm food plants
- » Rearing of silkworms for the production of raw silk
- » Reeling the cocoons for unwinding the silk filament
- » Other post-cocoon processes such as twisting, dyeing, weaving, printing and finishing.

In India, it is a village-based industry practiced in about 53,814 villages and provides employment to about 6 million people moreover it is capable of providing continuous income to farmers. Sericulture suits both marginal and small scale land holders because of its low investments, high assured returns, short gestation period, rich opportunities for enhancement of income and creation of family employment round the year. In India, due to favorable climatic conditions, mulberry is cultivated mainly in five states, viz., Karnataka, Andhra Pradesh, Tamil Nadu, West Bengal and Jammu & Kashmir. These five states collectively account for 97% of the total area under mulberry cultivation and 95% of raw silk production in the country. Tamil Nadu occupies fourth position in the country in silk production and now it is working with an aim to occupy third position. The annual silk production in Tamil Nadu is around 1400 Metric Tons. At present 23,691 farmers are practicing Sericulture in Tamil Nadu, cultivating 36,482 acres of mulberry which gives employment opportunities to 1,82,410 persons as on 31.03.2012.

The present global scenario clearly indicates enormous opportunities for the Indian Silk Industry. Sericulture is one of the most labor intensive sectors, combining activities of both agriculture (sericulture) and industry. At present 23,691 farmers are practicing Sericulture in Tamil Nadu and in reality, it is an occupation by women and for women because women form more than 60% of the workforce and 80% of silk is consumed by them. This study is undertaken to understand the participation of women in sericulture, factors which influenced them to venture into sericulture and the problems faced by them while starting and promoting the business.

Women in Sericulture

Gender empowerment in rural agro-industrial sector of India has been put special thrust in Indian economy and polity since 1990s as several foreign donor agencies enabled the formation of woman-oriented NGOs. Involvement of women in working force as well as in personal and social decision making process becomes a vital issue as the development arena of globalization started excluding all the marginal sections of the society, including women. The development gap between two strata, two different gendered identities become substantially wider and all these call for an inclusive development where the development impact can be reached to the marginal sections.

Sericulture is one of such activities which open up the scope of inclusive development through promoting the marginal sections, known as 'women'. Here, most of the works are carried out by women alone, both in terms of operations performed and time invested. Thus in a way, women contribute a significant role in different spectrum of work activities as well as in decision-making. While in general perception, women's role is mostly confined in silkworm rearing, in reality it goes beyond. Leaving the shackles of gender-stereotyping, women in sericulture often take part in mulberry planting, weeding, manuring, irrigating,

leaf picking, leaf transporting and storage. In silkworm rearing, they are engaged in leaf-cutting, feeding, bed cleaning, worm spacing, mounting, harvesting and disinfections. Some also participate in decision-making. Thus the dominance of women workers in sericulture is historically evolved. However, despite showing tenacity and persistence, their efforts remained unnoticed and they continued to work as unpaid family workers.

In recent years the role of women received increasing importance. The specific operations she performs as well as the magnitude of her production contribution have started being perceived and acknowledged more recently. The year 1994 had been declared as the 'Year of Women in Sericulture'. Through this special campaign, "women in sericulture" was brought on to the center stage of sericulture development. Later on, the developmental schemes conceived by Central Silk Board, India advocates greater thrust on women empowerment, promotion, awareness generation and support services.

The concept of gender budgeting introduced by the Government of India during Tenth Plan also led the Central Silk Board of the country to assess the adequateness of the allocation of resources for women and ensure that the gender commitment coupled with budgetary commitments are translated into achievements. The Eleventh Five Year Plan made a separate "women development component" mainly to address the social security concern of women associated with the silk industry.

Sericulture is an extremely labor intensive industry and occupies a pivotal position from the point of providing employment and additional income to weaker sections (Best & Maier, 2007; Bhatta & Rao, 2003; Geetha & Indira, 2011; Vijayanthi, 2002). In this context, the transformation of sericulture industry from subsistence type of operation to a modern scientific system requires the attention of all major players like policy makers, administrators, and personnel associated with the industry. Here, the word personnel mainly refers to women laborers who are the full-time workers and who look after silkworm rearing and management and whose contribution is more than that of men in this area. It has been reported that women contribute about 50% and 60% of labor to mulberry cultivation and silkworm rearing, respectively (Gate, 2001; Goyal, 2007; Kasi, 2011; Panda, 2007; N. Singh, 2006; Srinath, 2008; Thamizoli, 2001; V. Vijayalakshmi, 2002). It has been rightly observed by Inbanathan and Vijayalakshmi (1997) that from time immemorial, women have been involved in different sectors of the silk industry. According to a legend, the discovery of the silkworm and cocoon was by a beautiful Chinese princess. But for her foresight and imagination, perhaps, the silk industry would not have been what it is today. The industry is well established in the traditional countries like Japan, China, and Korea (Geetha & Indira, 2011). The progress has been equally rapid in the developed and underdeveloped countries. In India, sericulture is practiced as an agro-husbandry-based subsidiary occupation. From the household, women are employed in sericulture operations. As mentioned earlier, about 51% of women are assisting men in this lucrative industry to produce the "queen of textiles"

(Kannan, 1987). Women are mostly favored because of their industrious nature. They are employed in a mulberry garden or silkworm rearing or in a grainage or in weaving or in a garment-making factory, and so on. As mentioned earlier, sericulture offers a vast scope to augment the family income. Women are actively engaged in the mulberry fields for the removal of weeds and in leaf plucking. The leaf plucking is a skilled and delicate operation. The workers must have full knowledge about which leaves to be plucked to suit different ages of silkworms. Women go to the fields in the morning for plucking the mulberry leaves and return to the rearing house before noon. In the rearing house, it is not uncommon to find women folk assisting men in feeding the silkworms. Feeding is an art very aptly done by the fair sex, though men do chopping of leaves. Women assist in bed changing and they do this with utmost tenderness, so as not to hurt the delicate worms. Women have become experts in Chawki rearing, which is a highly delicate operation that needs to be performed with a great deal of care and patience. Good harvests depend on good Chawki rearing. When the silkworm matures and time is ripe for spinning the cocoons, it is again women who are employed for picking the ripe worms and putting them on the chandrikas (bamboo mountages on which silkworms are placed when they are just about to spin their cocoons). Any overcrowding will lead to an increase in the spinning of double cocoons, which would be unsuitable for the production of high-grade raw silk. When the cocoons are ready for harvesting, it is mostly women who sort out the flimsy, stained, double, and deformed cocoons from the chandrikas. Coming to the post cocoon technology, the involvement of women is greater, commencing from silk reeling, weaving, and garment manufacturing industry. Whether it is a charkha, cottage basin, steam filature, or automatic or semiautomatic reeling, women are preferred due to the dexterity of their fingers in getting the fine filaments from the cocoons, casting of the ends, and their patience to work in hot water and seam for long hours. It is really a touching sight to see women sitting near the boiling water all day long, reeling the crude charkha silk. Women's greater involvement in reeling industry is seen not only in India but also in all silk-producing countries. The ultimate success of the post-reeling operations depends much on good winding, that is, yarn without breaks. There should be continuity in the yarn. Otherwise there will be too many knots which hinder good weaving, be it on a handloom or a power loom. However, their work has not always been properly recognized or suitably rewarded. Cultural factors have complicated the proper evaluation of the quantum and quality of women's contribution. This includes elements such as the structure of work in each society, segregation of women and men in specific occupations, and the division of labor.

Work and Division of Labor Bose et al. (2009), in their sociological study, have clearly depicted the patterns of women's work and analyzed the factors that influence the gender division of labor. Furthermore, they viewed that the persistent gender division of labor in rural Bangladesh has been found to be associated with both economic and sociocultural factors. Rural economic activities within the household were found to have a weak impact

on women's empowerment. Earlier, Inbanathan and Vijayalakshmi (1997) rightly stated,

“Work is regarded in many ways in different societies, and, the conception of work has also varied from time to time. The transition from simple hunting and gathering communities to agrarian technology entailed a major shift in gender relations. The sociology of gender and, to some extent, sociology of work has attempted to explain the work of women by relating it to two realms prevalent in society. It has been argued that women's involvement with child rearing and domestic work was responsible for their exclusion from the public sphere.

It has been amply demonstrated that though women participated in both spheres of work context, they are still confined to “home-based” jobs than “outside home” jobs or tasks. Even in cases where they do both jobs, they are to be performed under the guidance or supervision of men. Their home-based jobs are not even considered as productive work and in the same vein, all home-based jobs done by women, including silkworm rearing, are relegated to a lower status and are virtually considered insignificant and unskilled. This also has a bearing on their decision-making power vis-à-vis men (Dankleman & Davidson, 1988; Inbanathan & Vijayalakshmi, 1997).

Reasons for dominance of women workers in sericulture:

Sericulture is practiced in villages of India as a family-based occupation and thereby provides women a major role to play with, in various activities of this household industry. Nearly sixty percent of the labour requirement is met by the women in almost all the traditional sericulture agencies in the world. Women's precision and patience make their presence more invincible in silk- worm handling. Since, traditions and customs of society in Indian rural context do not encourage the majority of rural women to work outdoors; sericulture proves to be a boon. It gives a wide opportunity where women can carry all their contributory work even after attending to their own regular household chores. Thus, sericulture is ideally suited for family women in the rural areas.

Farm women have certain unique attributes, which are of special relevance to sericulture development and that these characteristics make the female dominance in sericulture indispensable:

1. A farm woman is the sheet anchor of the farm family. She is the foremost member who is concerned all the time about the well being of the family. So when women dominance is seen in any activity that has to be turned out to be a successful one. Poverty in rural India is another key feature that makes the women from lower class more intensive and serious to the work and this also enhances their productivity.
2. Women are proved to be an efficient home-maker from the time immemorial. So whether as an artisan or a household industrial worker, she is supposed to give her best as it is involved with her family. Sericulture is such farm enterprises that have

a great share of indoor components and demand enough tenacity and sufficient attention. Thus female dominances in sericulture become quite natural.

3. According to the analysts, women have proven themselves to be better learners. They are easily adaptable which is important for a dynamic world where better sericulture technologies are about to pay better dividends.

Women empowerment: a vehicle of poverty eradication

It has been widely recognized in the Working Group's Report of XIth Plan that a pro-woman growth is the most effective route to poverty alleviation. The concept of gender budgeting had already been introduced by the Government of India in Xth Plan. The Central Silk Board has adopted gender budgeting to assess the adequateness of the allocation of resources for women in sericulture. Experts in this field opined that government should ensure its gender commitments and, accordingly, provide relevant budgetary support so that commitments can then be translated into achievements.

In rural India poverty becomes a natural phenomenon due to irregular monsoon. Frequent draught results into crop failures and that, in turn, increases the debt burden of the farmers to such an extent that even big farmers have been driven below the poverty line.

Agriculture itself fails to support such a high population in our country on full time basis. In such a situation sericulture is one such activity, where women carry most of the activities alone. In drought prone areas, where there is no scope of non-agricultural employment generation, sericulture proved to be an enterprise that has the potential to eradicate poverty through creation of employment opportunity for women.

Devaki Jain (2007) in exploring the gendered policy through her experience on Karnataka based activities, stated that women need to become economic and political agents instead of passive recipients of special ladder and safety nets. This she calls a "bubbling up model". Jain (2007) illustrated her points with examples from her work in Karnataka. To demonstrate the gender bias information, she uses the examples of poverty and sericulture programmes in Karnataka. Poverty programmes were based on data that did not adequately capture the extent of women's work or the double burden they faced in working home and at outside. Therefore, special studies and surveys were conducted to map gender inequalities within home and extent of women's work outside. This led to change in policy where programmes were modified to allow for direct targeting of women.

Rural women work participation is always assumed as a function of poverty, landlessness and few other non-economic factors (Nayyar, 1987). Women belonging to landless, marginal and small agricultural families are forced to seek employment. Thus poverty is considered to be a single most important factor of female participation. Landlessness is often synonymous

with poverty and hence the line of argument is that greater poverty induces greater female participation in productive work.

Hence, we can infer that higher participation in sericulture is also considered as an indicative phenomenon that poverty is acute in Indian status. We have already analyzed in the previous section that there lies a class differential among participating women in sericulture. However, the percentage of household women involvement also rises along with hired women. This confirms that sericulture not only augments welfare of impoverished section of people but it also works in gender promoting activity in rural India.

Involvement of Women in Sericulture:

Basic feature of this farm based economic enterprise is the involvement of women, Women contribution in sericulture industry is to the tune of 60 %, mostly in silkworm rearing and reeling. The production of quality bivoltine silk is still a challenge in J & K in spite of enormous potential and also to reduce the import of bivoltine silk to the country.

Infrastructure for sericulture:

The sericulture is the oldest department in J & K. The infrastructure available is discussed below:

- i. 30,000 rural families are practicing sericulture as subsidiary occupation and producing 1032.4 MT cocoons (Anonymous, 2014-15).
- ii. Rs. 2026.00 lakh is earned annually by the farmers without any role of middleman.
- iii. After demonopolization of the industry, the no. of reeling units in the private sector has increased to 34.
- iv. There are 173 departmental nurseries spread over an area of 963 of acres, and 374 mulberry blocks over an area 2215 acres across the state.
- v. The department has 374 mulberry farms spread over an area of 2215 acres, having mulberry wealth of 30 lakhs trees, helping landless people.
- vi. There are 9 basic seed farms and 6 grainages.

Schemes and Initiative taken by the state Govt. for promotion of sericulture in J & K:

The J & K state has taken many new initiatives for promotion of sericulture. Some of the initiatives are enumerated as:

1. Implementation of scheme 'Health Insurance for women' which aims at providing

insurance cover to the women engaged in silkworm rearing. 2500 women rearers were brought under this scheme during 2012 - 13.

2. Implementation of scheme 'Marketing support to cocoon growers' Rs. 32.10 lakh has been paid to cocoon growers as marketing support on account of low prices fetched by them.
3. Implementation of scheme 'Cluster Development Programme' 25 clusters are operational in the state under holistic approach for development of sericulture in the state.
4. Implementation of scheme 'Cluster Plantation' to augment area under mulberry plantation through farmers and on govt. land during the year 2012-13, 11.00 lakh plants (8.00 lakh plants through farmers and 3.00 lakh departmentally) were planted under the scheme 'support for raising of mulberry plantation' and similar no. of mulberry plants are being planted during financial year 2013-14 with enhanced unit cost of Rs. 5500 / 300 plants.
5. Implementation of scheme 'Supply of Rearing Kit' under catalytic development programme during the year 2012-13, 2000 silkworm rearers were provided with rearing kit under transfer of technology at a unit cost of Rs, 0.25 lakh under CDP and 1600 more beneficiaries are being covered during year 2013-14.
6. Implementation of scheme 'Technological advancement scheme' 20 number hot air dryer at a unit cost of Rs. 1.75 lakh were established in the state to facilitated cocoon drying by farmers on scientific lines by way of shifting the process from the conventional sun drying. This has helped farmers to fetch better prices for their produce.

Constraints:

In the study, efforts were also made to identify some major constraints related to participation of women in eri culture. Some of the major constraints documented during the study are discussed below:

1. **Lack of separate rearing house:** It was observed that majority of the farmers do not have a separate rearing house. As a result, they use to brush very less quantity of dfls (only 5-15 dfls per crop) in a corner of their living house.
2. **Lack of adequate plantation:** Although, the plantation is a primary requirement for rearing of eri silkworm, majority of the farmer do not have systematic plantation for rearing of silkworms. They use to collect leaves from naturally grown castor or kesseru plants from different places nearer to their home. As a result, the farmers cannot take up

the rearing in every season regularly. These farmers can conduct only 2-3 crops instead of 5-6 crops in a year.

3. **Lack of Improved technological knowledge:** Most of the farmers are not aware of the improved rearing technologies viz, high yielding silkworm variety, disinfection, improved rearing technology, etc. This results in low production of cocoons and generates low income.
4. **Inadequate time:** In case of the women belong to very low income group, it is obligatory to engage themselves in agricultural field for certain works like transplanting of rice, weeding, harvesting, etc. Sometimes, they use to works at others agriculture fields by taking wages. As a result, this group of women cannot participate continuously in the eri culture.

Table 37: Participation of Women in Sericulture Industry

S. No.	Year	Employment (In Lakh Person)	No. of Women (In Lakh Person)
1.	2000-2001	54.00	32.40
2	2001-2002	55.73	33.44
3	2002-2003	56.00	33.60
4	2003-2004	56.50	33.90
5	2004-2005	58.00	34.80
6	2005-2006	59.05	35.43
7	2006-2007	60.03	36.02
8	2007-2008	64.11	38.74

Source: Department of Sericulture Industry

Suggestions

Most of the women have education only up to school level hence they are unable to understand modern techniques in sericulture. They face problems like heavy work load and lack of time, hence effective and efficient training programs in nearby places can be organized by government and Sericulture department.

Women are facing financial problems in sericulture, so sericulture department and regional rural banks can make arrangements so that process involved in availing loans is simple and beneficial.

Sericulture department should come out with advanced technology and make women

entrepreneurs in sericulture to implement new technology in order to reduce the burden of heavy workload and labor problems.

Women must be encouraged to participate with timely and continuous support in all the activities of sericulture and also extra subsidies can be provided to promote sericulture business.

There is a need for commercialization of sericulture in order to compete in the world of new economic regime.

Conclusion

Even though the participation of Women is high in Sericulture industry and majority of the women entrepreneurs are satisfied with subsidies provided by government, still they face various problems while starting and promoting their sericulture business. Most of the women entrepreneurs involved in Sericulture have minimum educational qualification, so government and sericulture department can organize effective training and development activities for them, which will ultimately reduce the problems and also enable the women entrepreneurs to overcome the obstacles. Sericulture is one among the high income generating industry, hence promoting women entrepreneurs in Sericulture will lead to economic development and empowerment of women. Sericulture is most important for rural area, it creates the gain employment to the farmer and it is also providing a great opportunity to the poor and small area farmer to increase their economic condition. Sericulture is also providing employment for women in rural area. Sericulture is labour intensive activity and it also help to women's for self-development. Sericulture is the best occupation for women's in changing situation of environment. It is possible to have the women empowerment through sericulture industry. Sericulture is ideally suited for land and labour abundant economy like India, not only because it is low capital intensive but also because it is female labour intensive. Gender promotion and thereby social transformation along with poverty eradication is another major feature of this particular sector, through which inclusive development can be translated to these ignored sections of the society. Higher percentage of female labour can raise the gender dominance of the sericulture farms and gender dominance is associated with higher level of domestic female than hired female. But if the size of household rises and greater amount of workers are being attracted to join the sericulture farms, possibly due to higher returns, they crowd out the female workers. But the welfare impact of a female dominated farm is always redistributed to different sections of the society and a gross level of up-gradation in nutrition and education level is possible only through the spillover effect of this female employment generation. Therefore, holistic level of development is possible via gender promotion only. Development of women workers in this sector actually encompasses all those marginal poorer section where special thrust is urgently required. Gender discrimination against women worker in wage payment has to be legally banned. More incentive scheme

(like concession in taxation etc.) should be provided to the employer in order to raise the involvement of women worker in sericulture farms. Women workers intensive sericulture also needs some primary institutional support and initiatives so that sole-women (like widows, separated / divorcee, single) household members can survive. However, there always exists a major gap between policy resolution and policy implementation. Therefore restructuring the process of implementation is also at once required. Then only the gender promotion and inclusive development will be possible. Drastic change in mind set will be a necessity while implementing equal wage payment and ensuring female dominance in farms. Impact of inclusive development will then be felt, when at all activity level of sericulture, voice of working women can be clearly heard of.

MARKETING OF SILK, SILK GRADING, SILK REELING AND BY-PRODUCTS OF SERICULTURE

4.1 Marketing of Silk, Sericultural Marketing Organization, their Merits and Limitation

Introduction

The Indian sericulture market was worth INR 266 Billion in 2019. Sericulture refers to the art of rearing silkworms for the production of silk. India is currently the world's second largest producer of raw silk and the largest consumer of raw silk and silk fabrics.

The market for silk in India is driven by both exports and a very strong domestic demand. Fabrics made up of silk are quite popular in the domestic market during ceremonies, religious rituals, weddings, festivals, etc. Silk is used as a raw material for the manufacturing of both garments such as suites, sarees, etc. as well as in products such as curtains, bed sheets, pillow covers etc. Although silk is currently regarded as a luxury item in India with its price being significantly higher than other fabrics, we expect a continuous increase in disposable incomes to increase the consumption of silk fabrics in the country. Looking forward, IMARC Group expects the market to exhibit moderate growth during 2020-2025.

» Market

Market is a place or building where buying or selling of goods takes place. But in modern time with fast and long distance communication facilities like telephone becoming available,

market is no more restricted to a particular place only, but it has become wider and has assumed regional, national or even international status. Buying and selling is finalized on telephones or internet only from distant places. Thus, concept of market is radically changed.

Marketing

Marketing is the process in which buying or selling of goods takes place.

Sericultural marketing organization

The sericultural marketing organization is an organization that assist allow farmers to sell their goods (cocoons) and obtain money in a systematic way. The marketing organization particularly in sericulture is divided into two different sectors:

1. Regulated marketing
2. Co-operative marketing

Under the regulated markets the goods produced by the farmers are regulated and controlled by the state government through the market committee. It aims at the elimination of unhealthy cocoons, and unscrupulous practices, reducing marketing charges and providing facilities to producers and sellers in the market. The existence prevalence of various unexpected practices such as short weight, excessive market charges, unauthorised deduction, adulteration of produce and the absence of machinery to settle dispute between sellers and buyers are recognised as the main hindrance in this marketing system.

Regarding cooperative marketing when producers of sericultural commodities or any other product form a society with an objective of carrying out marketing of their production such society is called as co-operative marketing. The need for cooperative marketing organization arose due to many defects observed and experienced in the private and open marketing system such as malpractices prevail in marketing arbitrary deduction from the produce, manipulation of weights and measures and cheating the farmers, collusion between the broker and the buyer while fixing the price, delay in payment of amount due to farmers etc.

Merits

In Sericultural marketing organization the following merits can be observed:

1. Identifies needs and wants of customers.
2. Determines demand for product.
3. Price is fixed based on the visual observation of the cocoon in the market.

4. The farmers get the amount of their products (cocoons) sold on spot.
5. The seller is able to follow the bidding easily.
6. A wide variety of goods are available to buyers for selection.
7. The buyers of small lots are not put to demerits against the buyers of large lots.
8. The payments of the price of the goods (cocoons) are made immediately after the sale if an auction has been completed.
9. Provide better environment to the sellers (farmers) to sell them good in the market.

Limitations

Most small farmers do not possess suitable marketing means, and this is the main handicap to increased production.

Many of the farmers feel that they run too high a risk of not being able to sell their produce at a fair price. The traditional farmers need above all is to have faith in the marketing system. It is possible to conclude and we shall return to this point further on that one of the main ways of improving the farmer's productivity does not consist merely in improving the imports and the production on methods. It is paramount to secure a reliable market, a suitable price, and a system by way of which the farmer can market his produce, and at the same time receive the highest possible share of the price paid by the consumer for that produce.

Cocoon Marketing

Market is a regular gathering of people for purchase and sale of provisions, livestock and commodities. Cocoon market is a place where the buyers and sellers are required to transact cocoons by open auction under the regulation of law.

There are different types of cocoons market which are as follows;

1. Direct marketing
2. Co-operative marketing
3. Regulated marketing

1. Direct marketing or rayatha bazar

In direct marketing, the govt. involve directly or indirectly through agencies in marketing of silk. This system is followed in all the non-traditional silk producing states except Gujarat, Kerala and Orissa where co-operative system of marketing is followed. J&K and West Bengal

follow direct marketing system. The markets are mainly starts to establish direct link between the farmer and consumer. There is no place for middle man between the farmer and the consumer, because when goods are routed through middle man, the farmer will not getting remunerate prices for their products. The goods are sold at higher prices to the consumer. By eliminating the middle man, this scheme aims at benefiting both the farmer as well as consumer. The state govt. organized marketing of cocoons in Jammu and Kashmir. Here the rate is fixed for cocoon by simple quality test.

2. Co-Operative marketing system

In co-operative marketing system co-operative societies are involve in the marketing of silk. Gujarat, Kerala and Orissa followed this system. The need for co-operative marketing arose due to money defects observed and experienced in the private and open marketing system these are;

1. Several mall prices prevail in the marketing of produce.
2. There exist a chain of intermediates of between the producer and the final consumer. They include merchants, traders, wholesalers, commission agents, pre-harvester contractor and retailer. They take their own margins for the services they sender.
3. A co-operative marketing society provides market finance to the farmer and ensures better returns to their produce. Under the system of co-operative marketing whole responsibility of marketing is taken up by the farmer themselves, organized on co-operative basis. The area of operation of marketing society is usually fixed with reference to local condition. Co-operative market system prevails in Gujarat, Kerala and Orissa. Co-operatives collect green cocoons from the member by fixing the prize based on quality.

3. Regulated marketing system

This system of marketing is followed in the major silk producing states of India namely; Karnataka, Andhra Pradesh and Tamil Nadu. In regulated marketing system buying and selling of silk is regulated and controlled by the state govt. through the market committee. Karnataka passed an act known as “regulation of production supply distribution and sale act” in 1959.

Traditional and regulated markets of Seed, Cocoon, Raw Silk and Silk Fabric

1. **Traditional and regulated markets of seed:** The silkworm seed is the backbone of the sericulture industry and the quality seed plays an indispensable role for the successful harvesting of cocoon crop.

The silkworm seed or Dfls (Disease free laying-pebrine) is transacted or sold through the regulated market system organised by the central silk board (CSB) to cater the need of the farmers in a large extent. The selling of seed is take place under government as well as private sectors. The place where seed is being sold is called grainages (or) SPC Seed production centre in govt. Sector and in private sector LSP'S License seed producers, these centres are authorised by the CSB-Central Silk Board to sell the seeds under regulated marketing system to the farmers. The following salient features of these centres are:

- i. Supply disease free and quality seeds to the farmers.
- ii. Facilitate the farmers to purchase the seeds at a subsidised rate.
- iii. Meet the timely demand of the farmers, when needed.
- iv. Provide assurance of better cocoons harvesting.
- v. Some LSP,s provide door to door services to the cosumers (farmers)
- vi. No deficiency of seeds are felt to the farmers, while commercing or programming for the silkworm rearing.

2. Traditional and regulated market of cocoons: About 90% of the cocoons produced in India are transacted through the regulated market organised by the state sericulture department / CSB- Central Silk Board. The major cocoons producing states namely; Karnataka, Andhra Pradesh, Tamil Nadu almost the similar system of regulated market with regard to cocoons selling. Among the traditional states in producing the cocoons, Karnataka state has the most efficient marketing system were established in the state by enacting the Karnataka silkworm seed cocoon and silk yarn (Regulation of Production). Supply distribution and sale Act-1959. The exploitation of middlemen and private market operators were eliminated and the interests of rearers and reelers were protected by the act. The salient features of the act, which bring out the functions of the cocoon market, are as follows:

- i. No person can sell or agree to sell, purchase or agree to purchase at any other place except in the notified cocoon market.
- ii. Both the rearers and reelers should possess licence issued by the state department / CSB for selling and buying cocoons from modified cocoon market.
- iii. The farmer is free to sell in any cocoon market in the state wherever he likes.
- iv. The lot of cocoons brought by the rearer is issued with a bidding slip on which rate, weight, the total amount and market fee payable are entered as the transaction proceeds.

- v. The sale of cocoon is by open auction and the lot is deemed to be sold on the highest bidder, provided the rearer agrees to the price. If the rearer does not agree to the price, another auction is conducted (or) he is permitted to transact the cocoons in any other market or in the same market in the following days.
- vi. The cocoons are weighed in the presence of buyer and seller in the uniform container under the supervision of the market official.
- vii. The payment is made in the form of cash in the same day itself. A market fee of one percent of the total value of cocoons transacted from the reelers as well as rearers.

3. **Traditional and regulated market of raw silk:** The raw silk is transacted in the regulated markets called silk exchange' established in different places in southern India by the respective state government. In Karnataka, silk exchanges were established under legislation to provide regulated marketing system for raw silk yarn. Now there were two silk exchanges functioning in the state. The provisions of the act regulated to the silk yarn marketing are as follows:-

- i. Every reelers should bring the silk yarn to the silk exchange for sale and the trader should buy silk yarn in silk exchange.
- ii. The sale will be by open auction conducted by the officer of the DoS – Department of state / CSB.
- iii. Weighing of silk sold will be by accurate weighing machines maintained by the silk exchange.
- iv. Payment will be made in full and in cash by the buyers to the sellers in the presence of silk exchange officers; the buyers cannot take the silk out of market till the full payment is made.
- v. A fee of 2 % of sale value is collected as market fee from the buyers or traders.
- vi. Once the silk is brought to the silk market cannot be taken back by the reeler. However, of any reeler is not satisfied with the price offered he can withdraw his stock, until he gets goods market price or he can auction in next day of the following days.

4. **Traditional and regulated market in silk fabric:** Handloom industry in India is the largest economic activity in the unorganised sector, next to the agriculture. The transaction with regard to the silk fabric takes place under traditional market system as most of the silk fabric is made in handloom industry. There are about 3.5 million

handlooms in India and employ around 10 million people directly or indirectly. This sector is the livelihood of a large rural population in India. The silk fabrics are mostly woven on handlooms. Handloom silk fabrics are quite popular in the domestic market as well as for export. A wide range of silk fabrics are produced in the handlooms are exclusively for export. The main features of the traditional marketing in handloom industry in India is that besides being the largest employment generating industry handloom earns valuable foreign exchange to the country. The handloom fabric when marketed has its features of special liking in the affluent western countries. Handloom fabrics therefore enjoy a preferential tariff when exported to the European countries.

Government Intervention- Legislation and Implication

One of the major area in which the government intervene in the agricultural / sericultural marketing sector of the economy. The government was three ways it can intervene and help its producers (farmers). These ways include price policies, direct payment, and input policies. Price policies have the largest effect on producers. Tariff, quota and taxes are just a few examples of price policies. While these policies bring revenue into the government, in the end they hurt consumers. Each of these raises the prices of both imported and native goods. They are designed to help stabilize price and give the native producers a chance to compete with foreign goods.

Besides, there are many different types of input payments implemented by the government. They range from below-market grazing fees and below-cost rural electrification to fertilizers and irrigation subsidies to loan interest rates. These input policies are designed to give the nation's native producers an edge by making commodities more accessible to them. Many of these input payment tactics are implemented to lower costs and maximize output for producers.

The use of tariffs is another way that government intervene in the business sector. They help inefficient domestic producers by forcing consumers to pay unnecessarily high price for imported goods.

Subsidies and government loans are another method of intervention for the government, in this methods, money is taken from efficient producers and workers to keep inefficient producers in business. A second one reason that government improve policies on their agricultural / sericultural marketing sector is the belief that intervention can accelerate the rate of income growth investment policies. The provision of public goods, such as the research and development of new technologies and infrastructural development / (roads, school, health facilities etc.) are examples of public sector interventions essential for increased economic activity.

Legislation:

The sericultural marketing legislations are as under:

- » A large number of farmers / sellers will deal in heterogenous and differentiated form of a commodity.
- » No ill practices or cheating will take place.
- » Here business (means-selling of cocoons) is done as per the rules and regulations by statutory market organization. Market prices are fixed as per the visual observation / rules and regulation without any unconvinced to the farmers.

Implications:

There is no doubt that in any marketing there is motive towards profit involved at the same time the marketing is to be based in certain values, principles and philosophies such as offering just and fair prices to the farmers. The government intervention and legislation bring necessary reform along with proper price through regulated market systems which help in streamlining and smooth implementation of different programmes, the Central Silk Board (CSB) like NDDDB may act as a guiding agent. The research centres of CSB will assist in all levels in better implementation of programmes and extension activities.

Co-Operative Marketing System for Sericulture

Sericulture industry suffers from many production and marketing problems like lower productivity, poor quality at different stages of production and processing, imbalance in demand and supply at different regions, price fluctuations etc.

Co-operative movement has made significant breakthrough in the various agro-based industries in India. The 'White Revolution' in India is mainly characterised by the co-operative movement in Dairy. Farming under a well-known programme known as Operation Flood (OF). Problems faced by dairy industry were similar to that of silk industry and the co-operative approach has made it possible to overcome the same. A need was felt for systematic and organised approach in order to establish proper linkage at various stages of silk production to enhance and stabilise production and productivity, quality control and better distribution of income.

Co-Operatives in sericulture

Though co-operatives took birth in 1904, large scale cooperatives were started in 1954 after a survey conducted by the Reserve Bank of India. Looking at the encouraging performance of co-operatives in other sectors it was felt to organise cooperatives in sericulture field. At

present co-operatives are functioning at various levels viz.:-

1. Co-operatives chawki rearing centres
2. Farmers-cum-sericulturists co-operative society.
3. Reelers Co-operative Society.
4. Cocoon and Raw Silk Co-operatives
5. Weavers' Co-operatives Societies.
6. Multipurpose Co-operatives.
7. It has been observed that during second five year plan period 110 sericulture societies were registered. All the above cooperatives were organised mainly in traditional states and functioning independently, without any linkage among themselves. These co-operatives have been organised with specific objectives and the organisational setup depending on their purpose and size.
8. The functions and facilities in accordance with the needs of their members.
9. The overall review of the presently existing co-operatives reveals that most of these co-operatives have emerged due to the sell needs and non-availability of such facilities in the government organisations. There is no horizontal or vertical coordination among these co-operatives. There is thus a need to channelize the sericulture co-operatives, in one stream.
10. This calls for a systematic organisation of co-operatives at various levels.

Marketing Constraints in Sericulture

Though the enforcement of Silkworm Seed Legislation Act (1959) in Karnataka state has overcome the anomalies in cocoon marketing, yet the act is not introduced in several sericultural states. The price fixation followed presently for the cocoon lots is not based on systematic grading but by visual inspection and open auction. Hence, it is the middlemen who ultimately decide the price. Highly elastic price fluctuations have been observed at different seasons/ months. The variation is also observed from market to market during the same period. The cocoon price is mainly influenced by internal and external factors like total arrivals, season, raw silk price, number of buyers and quantum of import of raw silk. Though, the formula for fixing cocoon price "Kakeme Cost" has been established, it is not being used at present marketing system.

There is no strong linkage among the marketing system, input supply and services

and financing institutes. There is a need for such facilities under one roof for facilitating sericulturists. This would, not only ensure timely supply, of inputs' and services but also help in large scale adoption of improved technology, increasing the productivity.

There is a considerable local demand for graded bivoltine silk (A or AA grade) which also has export value. But the cocoon market price statistics indicate that bivoltine cocoon yields being lower fetched lower price than improved cross-breed cocoons, although they have lower silk content. This has resulted in unsatisfactory bivoltine programme under NSP. Co-operative units of the above type would ensure better price based on quality and help to create demand for good quality cocoons like bivoltine and bridge the gap between supply and demand for high quality silk production.

The success story of Operation Flood Programme calls for the introduction of such model co-operatives for sericulture where many of the problems are similar to that of dairy industry.

Co-Operative Organisation Structure Model for Sericulture

A three-tiered structure can be for the sericultural co-operatives viz.

- a. The primary rearers and reelers' co-operative society,
- b. The primary twisters and weavers' co-operative society
- c. The Rearers and Reelers' Co-operative Union.
- d. The Twistlers and Weavers' Co-operative Union, and the State Silk and Cocoon Marketing Federation.
- e. The Twistlers and Weavers' Co-operative Union, and the State Silk and Cocoon Marketing Federation. (e) The rearers and reelers have a common channel and the twistlers and weavers have a common channel. This is done considering the fact that both the rearers and reelers are distributed in the sericultural belt (mulberry) whereas, twistlers and weavers are widespread over different places and different states in the country.

Organisation Setup-A Proposed Model

The Primary Co-operative Society at village level consists of members within the village(s) jurisdiction. In Rearers Co-operative Society, the silkworms rearers are the members. The society has management committee of nine representatives elected by the members for a term of three years of which one be the Chairman. The Management Committee appoints a Secretary, an assistant and other technical staff. The staff is trained in its technical knowhow in sericulture to meet the day to day needs of the rearers.

The Co-operative Union represents all the primary cooperative societies, the Chairman of which is a member of the Union. The Union is managed by a management committee consisting of 19 Directors elected by the members of the union, which in turn elects its own President. The Union have large professional staff managed by the Managing Director. Under Rearers Co-operative Union, there are many stifling centres spread throughout the district.

Through these stifling centres, the services of the union are rendered to all the primary co-operative societies.

In the co-operative structure, the Sericulture Marketing Federation forms the third tier for centralised operation at state level. The Presidents of different district unions are the members of the Federation. The Federation is again managed by an elected body. The Federation have large professional staff managed by Managing Director.

For implementation of different programmes, the Central Silk Board (CSB) like NDDDB may act as a guiding agent. The research centres of CSB will assist in all levels in better implementation of programmes and extension activities.

Marketing Institutions – Marketing board – Co-Operative with special reference to J & K state

A marketing board / institution is an organization created by many producers to try to market their product and increase consumption and thus prices. Marketing boards often also receive functioning from government as a subsidy. The leadership and strategies of the marketing boards also sometimes act as a pool, controlling the price of farm products by forming a legal cartel. They also fund other ventures beneficial to their members such as research.

For safeguarding the interest of rearers the Govt. of J & K has also passed an act with a view to regulate the transaction of cocoons in the market through auction. More or less functioning of these markets; transaction of cocoons and raw silk as similar as income of other states.

Cooperatives in sericulture industry form a part of the industrial cooperative sector. Keeping in view of the progress of its development. It has been seen that the entire sector of village and small industries has increased from 7011 to 33256 societies within 10 years but similar progress of sericulture co-operative societies could not be made at the end of the second five year plan, a total 110 sericulture societies were registered.

There are different types of sericulture cooperatives like:

1. Chawki rearing co-operative
2. Seed production co-operative

3. Credit and sericulture co-operative
4. Cocoon and raw silk co-operative
5. Handloom weavers co-operative

The General objectives of Co-Operatives are to provide employment to its members to improve their conditions by:-

1. Raising funds required for its activities.
2. Purchasing raw materials and appliances required and distribute them on cash or credit to members.
3. Getting raw materials converted into finished products members.
4. Purchasing or receiving for sale the finished products from the members and sell them at a higher price.
5. Conducting workshop's to facilitate members and their industry.
6. Obtaining contacts from govt., public sectors another bodies for the supply of raw materials and get them executed that or with the help of members.
7. Providing dwelling houses and houses sites to workers, members and staff, layout streets and roads and provide and maintain for facilities to water supply drainage, lighting and similar works of common utility.

There is a vast potential of Co-Operative for the development of sericulture which need to be extracted.

Summary

Based on the segment, the market has been segregated as Mulberry and Vanya. The Vanya segment has been further segregated as Tasar, Eri and Muga. Mulberry currently represents the biggest segment. Despite being the world's second largest producer of silk, the demand of silk outpaces its supply in India. The current gap between production and demand is currently met by imports. On the basis of application, the market has been segmented as natural silk yarns, fabrics and made-up; readymade garments; silk carpets; and others. Silk yarns, fabrics and made-up currently represent the largest application area. The market has also been segmented on the basis of various states. Karnataka was the leading producer of mulberry silk, whereas Assam is currently the largest producer of Vanya silk. The competitive landscape of the market has also been examined in the report.

4.2 Silk Grading: Brief Account of Silk Conditioning and Testing of Silk: Methods of Testing

Raw Silk Grading

Raw silk is a thread reeled from several cocoons and is understood to be a continuous thread. Classification of raw silk is an important test for raw silk testing. It supplements the test as well as the external visual observation and other product quality test results. The comprehensive evaluation is done as per the international stipulated grades standard like 6A, 5A, 4A, 3A.....F total 11 are used to express graded and upgraded raw silk product quality. For classification purposes, raw silk is divided into three categories according to their sizes:

- » 1st category : 18 denier and below
- » 2nd category : 19 denier to 33
- » 3rd category : 34 denier and above

Objectives

- » Finding out the correct mercantile (trade / commerce) weight of raw silk by the process of conditioning avoids confusion and misunderstanding between the seller and buyer.
- » Testing and classification ensures equitable transaction.
- » Raw silk would be tested and graded by an impartial organization and each graded lot would bear a detailed certificate of quality, it would enable even a distant purchaser to obtain the exact quality merely communicating by letter to the seller the specifications of the quality required.
- » It reveals to the reeler, the preference of the purchasers for particular qualities and thus guides the reeler to plan for production of only the required qualities in demand.
- » Testing and grading directly help to measure the progress of the reeling industry in particular and the sericulture industry in general and thus open scope for research and development to ensure strengthening of links to the industry.

Silk Conditioning

Silk is highly hygroscopic in nature. Therefore, it absorbs moisture to the extent of 15-20% during the days of high humidity like rainy season. During dry season, the moisture content in the silk will be very low. However, in standard atmospheric conditions *i.e.*, at 27 °C

temperature and 65% RH, silk absorbs about 11% moisture. So, in order to avoid loss/gain either to seller or buyer, the silk is conditioned to have standard moisture content of 11% in it. Silk conditioning is done in a conditioning oven. Conditioning oven is a chamber with special arrangement for drying raw silk under controlled conditions. It is capable of drying raw silk suspended inside at 140 °C and expelling moisture by forced ventilation.

After conditioning the silk, final weight is calculated by using formula;

Silk Testing

Silk weaving has reached a very high standard of industrial efficiency. Today a number of varieties of silk fabrics are produced on handlooms and sophisticated power looms. To achieve the success level of weaving industries, quality of raw silk is required which can only be achieved by silk testing. The testing of raw silk is based on the procedure laid down by the International silk association.

Silk Testing and Conditioning Houses

- » Central Silk Board has established full fledged Silk Conditioning and Testing Houses in some of the main sericultural states to inculcate quality consciousness in the silk industry.

There are five silk conditioning and testing houses;

1. Kashmir - Jammu & Kashmir
2. Malda - West Bengal
3. Bangalore - Karnataka
4. Dharmavaram - Andhra Pradesh
5. Kancheepuram - Tamil Nadu

Besides these, there are two more state level silk conditioning and testing houses in Bangalore (Karnataka) and Kolkata (West Bengal) for routine testing of raw silk in the country.

Methods of Testing

Raw silk test can be broadly classified into:

1. Quality test
2. Quantity Test

Quality Test includes; Visual test and Mechanical test.

a. Visual test

Visual examination forms the first test used in the grading of raw silk. The entire lot is examined for uniformity of colour, lustre and 'handle' (feel). This test is conducted on the whole lot of raw silk. This is carried out in an inspection room which is well illuminated. The inspection is carried out for following characteristics of uniformity, general finish and nature.

Each skein is examined for

1. Reeling defects (gum spots, gummed skeins, irregular traverse and double ends),
2. Finish defects (improper lacing, dropped ends, disturbed traverse, loose ends and double skeins).
3. Make-up defects (irregular skeins, improper skein twisting, raised threads, cut ends, streaky threads, gum knots and foreign matter on skeins).
4. Damage defects (friction damage, insect eaten threads, discoloured skeins, soiled thread, deformed books and gummed books. All these defects are included in the raw silk grading. The general finish of a lot is indicated as good, fair, poor or inferior.

b. Mechanical test: Mechanical test includes:

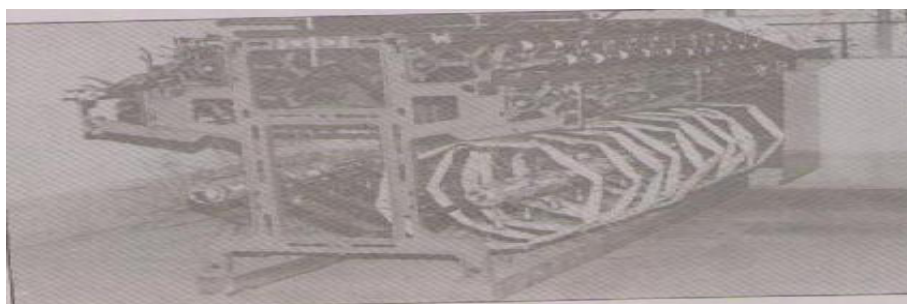
1. Winding test
2. Size deviation test
3. Serigraph test
4. Seri plane test
5. Tenacity and elongation tests
6. Cohesion test

1. Winding test

The aim of winding test is to determine the no of breaks which occur in the raw silk threads for certain periods of winding & physiability of the skeins for the winding. Winding is done on a frame which is capable of adjusting to a winding speed of 110,140 & 165 mtr/min. Equipments required for winding test are: winding frame and wheels and bobbins. The average winding speed, the breaks counting period and the time of the preliminary winding operation, is determined by the size under test are as follows:

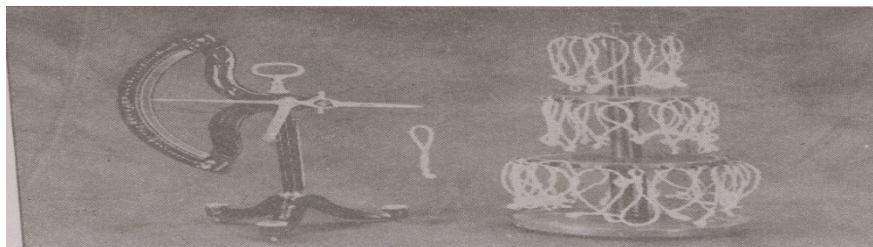
Table 38: Average speed and winding period for winding test

Size under test Tex (or denier)	Average m/min	Breaks counting period in minutes	Preliminary winding period in minutes (only inner)	
		Skeins 70 g each	Skeins of 140 g each	
1.3 tex (or 12 d) or below	110	60	120	10
1.4 to 1.9 tex (or 13 to 18d)	140	60	120	10
2.0 to 3.7 tex (or 19 to 33d)	165	60	120	10
3.8 to 7.7 tex (or 34 to 69 d)	165	30	60	5
7.8 tex (or 70 d) or above	165	20	40	5

**Figure 69: Winding Frame**

2. Size deviation test

Equipment required: sizing reel (1:125mtrs in circumference), balance & denier scale. Only fixed length from each skein is taken for the testing. The test consists a test for average size, size deviation and maximum size deviation test. Objective of size deviation is to determine the degree of size variation with the test pieces of sizing skeins of definite length of raw silk while max. Deviation test determines the extreme degree of variation. Measuring machine for making sizing skein shall have circumference 112.5 mtr at constant speed of 300rpm.

**Figure 70: Denier Scale**

3. Seriplane test

Tests are conducted with the help of seriplane winding machine, seriplane inspection board, illumination apparatus (standard photographs). Inspection boards, flat board 1m in perimeter upon which the inspection panel may be wound have a uniformly black flat surface without stripes width- 46 mtr, length- 150 mtr, circumference (width + edges thickness) -100 mtr. Seriplane winding machine used to wound raw silk on inspection board with uniform spacing & speed of 100 revolutions/m. Seriplane test includes: Evenness test, cleanness and neatness test.



Figure 71: Seriplane

- a. **Evenness test:** Its also called evenness level or evenness defect test. It uses silk yarn of different of a definite length and as per different sizes & as per specified distance arrangement and count, continuously combines these & binds on the seriplane. Objective of this test is to determine the frequency of size accuracy in raw silk threads with the approx. same length and sizing skeins. These are those defective portions of raw silk threads shows strips on inspection board caused by variation of the size of raw silk to such a degree as in early noticeably by visual inspection. Evenness variation test samples are divided into 3 groups according to the degree & frequency of size variations.

Evenness variation I

Evenness variation II

Evenness variation III

- b. **Cleanness test:** The bad cleanness not only increases the problems during the process of winding, twisting, weaving, increase in broken ends, reduce efficiency etc. The objective of this test is to determine the kind no. of cleanness defects of raw silk. They are classified into 3 groups:

A. Super major defects

B. Major defects

C. Minor defects

A. Super- major defects: are those which are 10 or more times as large as minimum size of major defects in length or size.

B. Major defects: These are divided into five as follows:

- i. **Waste:** This is a mass of tangled cocoon filaments or fibres attached to the yarn.
- ii. **Larger slugs:** These are somewhat thickened places in the thread 7mm and in length, or very badly thickened places shorter than 7mm.
- iii. **Bad casts:** These appear as abruptly thickened places in the yarn due to cocoon filaments not properly adhering to the raw silk yarn, or caused by feeding more than one cocoon filament at a time.
- iv. **Very long knots:** These are knots, which have loose ends, 10mm and over, or those made by incorrect tying of threads.
- v. **Heavy corkscrews:** Are places in which one or more cocoon filaments are longer than the rest, and give the appearance of a very coarse and large spiral.

C. Minor defects: The minor defects are subdivided into four as follows:

- i. **Small slug:** Which are considerably thickened places in the thread from 2 to less than 7 mm in length, or extremely thickened places less than 2mm in length.
- ii. Long knot are knots, which have loose end below 10 and more than 3mm in length.
- iii. Corkscrews are places in which one or more cocoon filaments are longer than the remainder, and give the appearance of a thick spiral.

Long loops or loose ends are loops or split ends, 10mm and above in length, when measured along the filaments.

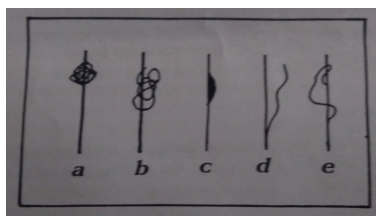


Figure 72: Various cleanness a) Waste b) Slug c) Bad casting d) Split ends e) Large loop.

c. Neatness test

Imperfection in raw silk yarn, which is smaller than those of minor cleanness defects. Test method;- test is conducted by inspector, from a position of 0.5mtr(2feet) distance in front of the inspection panels, under lighting. Each panel of any one side of the inspection board is carefully compared with the standard photographs for neatness defects and its neatness value is estimated in percentages. The object of this test is to determine the neatness percentage. Imperfection in raw silk yarn, which are smaller than those describe as minor cleanness defects are known as neatness defects. This defect includes:

- » **Nibs** are small thickened places or spots in the yarn less than 2 mm in length
- » **Loops** are small open places in the yarn caused by the excessive length of one or more cocoon filaments, less than 10 mm in length when measured along the filament.
- » **Hairiness or Fuzziness** is the conditions of yarn, which show small loose ends of less than 10mm and fine particles of cocoon filaments protruding from the yarn.
- » **Small knots** are knots, which have loose ends, less than 3mm in length.
- » **Fine corkscrews** are places in which one or more cocoon filaments are longer than the remainder and give the appearance of a spiral.

4. Serigraph test

Objective of the test is to find the tenacity and elongation test of the raw silk. To test the strength of the raw silk, breaking point (g per denier) and the degree of elongation (percentage) is carried out on the serigraph. Test method ; the sizing skein to be tested or placed in a room, where standard humidity can be maintained for a sufficient amount of time to allow them become adjusted to standard conditions. Each sizing skein is then tested for tenacity and elongation test using serigraph in standard humidity.



Figure 73: Serigraph

5. Tenacity and elongation tests

Tenacity of raw silk is indicated by the load, the thread can withstand just when it breaks in relation to its size. This value is expressed in terms of g/denier or per tex. Raw silk has sufficient strength to withstand the stresses imparted during various mechanical processes. Serigraph is used to measure tenacity and elongation. The unique synthesis of strength and fineness make silk very useful in certain important sectors, such as surgical field and fabrication of precious equipments. Silk fibre is also highly extensible. Therefore determination of strength and elongation of raw silk is an important test. Breaking load i.e. the load, the thread can withstand and just when it breaks is expressed in terms of gram per denier is called as Tenacity and is expressed as gram per denier in this test. To test the strength of raw silk, the breaking point (g per denier) and the degree of elongation (percentage) is carried out on a Serigraph. The test is conducted in a room, which is maintained at a standard temperature of 20°C and a humidity of 65 per cent. The tenacity is expressed in grams per denier, while the elongation is expressed in percentage of total stretch of the portion tested.

6. Cohesion test

Composite raw silk thread is not twisted during reeling. The individual filaments are combined mainly by the sericin content in the silk fibre. When the cocoons are cooked in boiling water, the sericin is softened. The sericin adhering to the filaments dries after reeling on exposure to air and causes the filament to agglutinate into the thread. The cohesion is measured by subjecting the raw silk threads to friction in the Duplon Cohesion Tester and counting the number of strokes required to spread and open out the constituent filaments. This test is not required for raw silk coarser than 34 denier. Continuous raw silk thread is placed in a zig-zag manner between a set of ten hooks on each side of the frame at a uniform tension in such a way that the thread can be subjected to friction action at 20 different places simultaneously and the number of strokes automatically gets reduced the total load given for tension is 180g, the test should be performed in standard atmosphere.

$$\text{Average cohesion strength} = \frac{\text{The total cohesion strength of raw silk under test}}{\text{The thread count of raw silk under test}}$$



Figure 74: Duplon Cohesion Tester

» **Quantitative test**

1. Conditioned weight test

The objective of this test is to determine the conditioned weight of silk which would assist in a fair transaction of silk. It has been determined that silk absorbs 11% moisture under standard ambient conditions. Conditioning essentially consists of desiccating the silk completely by exposing the silk to the action of dry hot air at a specified temperature (Textile material = 105°C and silk = 140°C) in a specially designed conditioning oven or conditioning chamber. The conditioned weight of raw silk is defined as moisture free or dry weight plus 11% of dry weight of silk. Raw silk is hygroscopic which means that it absorbs moisture readily from atmosphere depending on relative humidity and temperature. It has been determined that silk absorbs 11% moisture under ambient conditions. The object of this test is to determine the conditioned weight of silk which would assist in a fair transaction of silk.

The conditioned weight of raw silk is obtained as follows:

1. All skeins of raw silk for the test are put into a room with constant temperature and humidity for 12 hours. 20 skeins are picked up for a test unit and are then weighed separately as the original weight.
2. Two skeins are selected from the sample for the conditioned weight test.
3. The sample skeins are dried in an oven one by one with the drying temperature at 140°C. The drying is continued until the difference at very weighing (every 5 minutes) is within 0.1g.

Moisture regain is calculated as follows:

$$\text{Moisture regain \%} = \frac{(\text{original weight} - \text{dry weight})}{\text{Dry weight (g)}} \times 100$$

2. Boil off test for raw silk

The object of this test is to determine the percentage of sericin and water soluble substance of raw silk.

3. Exfoliation test for raw silk

Exfoliation is defined as the undesirable property of individual silk filaments which split into fine fibrils. These fibrils absorb less dye stuff compared to the main fibre and these appear as white fuzz on the surface of the yarn or fabric. This test determines the degree of fibrillation in raw silk. The Exfoliation test is made on raw silk and the degree to which the raw silk tends to exfoliate can thereby be determined. The sample for Exfoliation test consist of twenty original skeins drawn at random, an equal number from each bale of the lot, from different parts of the bale.

$$\text{The average point of exfoliation} = \frac{\text{The total number of marks number on each panel}}{\text{The total number of silk panels (20)}}$$

As per ISA (International Silk Association)

The raw silk is classified into three categories according to the size of the yarn for grading purpose (Tables 39 to 41).

Methods of grading

Primarily the tests are first classified as major tests and auxiliary tests. For Category I and II, size deviation, evenness variation I, evenness variation II, cleanness, average neatness and low neatness tests are considered as major tests.

For Category III, size deviation, maximum deviation, evenness variation I, evenness variation II, cleanness, average neatness and low neatness are considered as major tests.

For Category I and II maximum deviation, evenness variation III, winding, tenacity, elongation and cohesion tests are considered as auxiliary tests.

For Category III, evenness variation III, winding, tenacity, elongation and cohesion tests are considered as auxiliary tests.

Table 39: Classification for raw silk of category - I (18 denier and finer)

ITEMS	GRADE	4A	3A	2A	A	B
SIZE	12d and above	0.80	0.95	1.10	1.35	Above 1.35
Deviation	13d - 15d	0.90	1.05	1.25	1.50	Above 1.50
(Denier)	16d - 18d	1.00	1.20	1.40	1.70	Above 1.70
Evenness Variation I (Count)		150	170	190	210	Above 210
Evenness Variation II (Count)		10	17	26	37	Above 37
Cleanness (%)		97	95	93	88	Below 88
Average Neatness (%)		94	92	90	87	Below 87
Low Neatness (%)		90	87	83	77	Below 77
ITEMS	CLASS	(1)	(2)	(3)	(4)	(5)
MAXIMUM	12d and below	2.2	2.6	3.0	3.6	Above 3.6
Deviation	13d - 15d	2.4	2.8	3.3	4.1	Above 4.1
(Denier)	16d - 18d	2.7	3.2	3.8	4.6	Above 4.6
Evenness Variation III (Count)		0	2	2	6	Above 6
ITEMS	CLASS	(1)	(2)	(3)	(4)	
Winding	12d and below	7	15	25	Above 25	
(breaks)	13d - 18d	5	12	21	Above 21	
ITEMS	CLASS	(1)			(2)	
Tenacity (grams)		3.7			Below 3.7	
Elongation (%)		18			Below 18	
Cohesion (strokes)		40			Below 40	

Table 40: Classification for raw silk of category - II (19 - 33 denier)

ITEMS	GRADE	4A	3A	2A	A	B
SIZE	19d - 22d	1.15	1.35	1.60	1.95	Above 1.95
Deviation	23d - 25d	1.30	1.50	1.80	2.20	Above 2.20
(Denier)	26d - 29d	1.40	1.65	1.95	2.35	Above 2.35
	30d - 33d	1.50	1.75	2.05	2.50	Above 2.50
Evenness Variation I (Count)		150	170	190	210	Above 210
Evenness Variation II (Count)		10	17	26	37	Above 37
Cleanness (%)		97	95	93	88	Below 88
Average Neatness (%)		94	82	90	77	Below 87
Low Neatness (%)		90	87	83	77	Below 77
ITEMS	CLASS	(1)	(2)	(3)	(4)	(5)
MAXIMUM	19d - 22d	3.1	3.6	4.3	5.3	Above 5.3
Deviation	23d - 25d	3.5	4.1	4.9	5.9	Above 5.9
(Denier)	26d - 29d	3.8	4.5	5.3	6.3	Above 6.3
	30d - 33d	4.0	4.7	5.5	6.8	Above 6.8
Evenness Variation III (Count)		0	1	2	6	Above 6

ITEMS	CLASS	(1)	(2)	(3)	(4)
Winding (breaks)		4	10	18	Above 18
ITEMS	CLASS	(1)			(2)
Tenacity (grams)		3.7			Below 3.7
Elongation (%)		18			Below 18
Cohesion (strokes)		60			Below 60

Table 41: Classification for raw silk of category - III (34 denier and coarser)

ITEMS	GRADE	4A	3A	2A	A	B
SIZE	34d - 49d	2.60	3.10	3.65	4.45	Above 4.45
Deviation	50d - 69d	3.75	4.40	5.2	6.35	Above 6.35
(Denier)	70d - 18d	4.45	5.25	6.2	7.60	Above 7.60
Maximum	34d - 49d	80	9.5	11.0	13.5	Above 13.5
Deviation	50d - 69d	11.0	13.0	15.5	19.0	Above 19.0
(Denier)	70d - above	13.5	16.0	18.5	23.0	Above 23.0
Evenness Variation I (Count)		150	170	190	210	Above 210
Evenness Variation II (Count)		10	17	26	37	Above 37
Cleanness (%)		97	95	93	88	Below 88
Average Neatness (%)		94	92	90	87	Below 87
Low Neatness (%)		90	87	83	77	Below 77
ITEMS	CLASS	(1)	(2)	(3)	(4)	(5)
Evenness Variation III (Count)		0	1	2	6	Above 6
ITEMS	CLASS	(1)	(2)	(3)	(4)	
Winding 34d – 69 d		1	6	13	Above 13	
(breaks) 70 d and above		0	4	10	Above 10	
ITEMS	CLASS	(1)			(2)	
Tenacity (grams)		3.7			Below 3.7	
Elongation (%)		18			Below 18	

As per BIS (Bureau of Indian Standards)

The Bureau of Indian Standards has recognised two classes namely;

Class –I & Class –II for the purpose of grading, while Class-I refers to quality of raw silk reeled on filature or cottage basin and graded on International basis. Class-II refers to quality of raw silk reeled on charkha and graded to confirm to requirements of domestic use.

a. Grading of Class –I raw silk

Based on the size of raw silk, designations of grades are listed:

For raw silk of size 2, Tex (or 18 denier) or finer, the list of grades in the order of merit is 6A, 5A, 4A, 3A, 2A, A, B, C, D. Of these grades 6A is the highest and D is lowest. For raw silk of size 3.8 tex (or 34 denier) and above the list of grades is 4A, 3A, 2A, A, B, C, D and E. Of these 4A is the highest and E grade is the lowest.

1. Determination of grade of raw silk for 18 denier & 19- 33 denier

If the results of visual and tactile examination show that the lot is inferior in uniformity or the general finish or both, the lot is graded as D for 18 denier or finer and graded as E for 19 to 33 denier category. Further if number of breaks in the winding test exceeds the limit as mentioned below, the lot is graded as D for 18 denier category.

Table 42: Determination of grade of raw silk for 18 denier & 19- 33 denier

Size	Breaks
1.8 tex (or 12 denier) or finer	50
1.4 tex to 2 tex (13 denier to 18 denier)	40

For 19 – 33 denier category, if the number of breaks in winding exceeds 35, the lot is graded as E.

2. Determination of grade of raw silk for 34 denier or above

If the results of visual and tactile examination show that the lot is slightly inferior, then the grade is lowered to next lower grade. Further, if the results indicate that the lot is inferior in uniformity or general finish or both, the lot is graded as E.

In case the numbers of breaks in winding test exceed the values mentioned below, the lot is graded as E.

Table 43: Determination of grade of raw silk for 34 denier or above

Size	Breaks
3.8 to 7.7 tex (or 34 to 69 denier)	20
7.8 tex (or 70 denier) or coarser	19

Table 44: Requirements of the two classes of raw silk

S. No.	Class I raw silk	Class II raw silk
1	No admixture of different commercial varieties of raw silk.	No admixture of different commercial varieties of raw silk.
2	Not adulterated in any manner.	Not adulterated in any manner.
3	In reeling, the raw silk is carefully cross reeled on reels of 150 cm circumference to produce hanks of 70 or 140g.	In reeling, the raw silk is carefully cross reeled on reels of 150 cm circumference to produce hanks of 50±5g.
4	Suitable number of skeins are made into neat books each weighing approximately 2 kg, on a book making machine. Thirty books are wrapped with a cotton and jute cloth and packed into a bale.	A suitable number of skeins are made into a book weighing approximately 2 kg on a book making machine. Ten such books are wrapped in a cotton and the whole parcel is covered with jute cloth to make a bale.
5	The net mass of silk in a bale is 60 kg.	The net mass of silk in a bale is 20 kg.
6	All the bales are marked with the universal count, in tex and denier within brackets.	All the bales are marked with the universal count, in tex, and denier within brackets.
7	Raw silk reeled on multi-end / cottage basin.	Raw silk reeled on charkha (crude or improved).

b. Grading of class II raw silk:

Grade of class II raw silk is similar to class I raw silk. For class II raw silk, six grades from C1 to C6 and defined; C1 being the highest and C6 is being the lowest grade.

Suggestions for Improving the Quality of Raw Silk**a. To improve uniformity in the colour of raw silk**

- » The cocoon size, colour and shape of the cocoons in different lots must be the same for mixing them.
- » Melted cocoon in the lot have to be separated.
- » Water in the cooking / brushing bath has to be clean.
- » Combining new cocoons, partially reeled cocoons per reeling end will result in uniform colour.

- » Do not mix silk from different lots.
- » Do not mix cocoons from different lots without knowing its quality.
- » Do not use common water bath for cooking and brushing as water get turbid very soon.

b. To improve the uniformity in lustre of raw silk

- » Do not purchase cocoon lots with large quantity of melt and stained cocoons.
- » Separate the defective cocoons.
- » Water in the cooking and brushing bath should be clean.
- » Appropriate level of drying of raw silk during re-reeling.
- » Incorporate the required croissure length.
- » Do not mix silk yarn lots.
- » Do not cook/brush in a very dirty bath.
- » Do not reel cocoon mixed with melt cocoons.

c. Uniformity in handle

- » Variation in handle (softness / roughness) of skeins is found when silk skeins from different lots are mixed.

d. To avoid gum spots in the yarn

- » Incorporate drying methods of silk hanks at re-reeling.
- » Maintain temperature at 40 to 45°C uniformly at re-reeling.
- » Retain re-reeling speed of 150 rpm (maximum).
- » During skein finishing tease out the hard gum spots between the fingers.

e. To avoid loose ends in a skein

- » Remove hanks from re-reeling carefully such that the yarn does not get hooked to machinery parts or the worker's wrist watch, shirt button, rings, etc. and get pulled.
- » Tighten the collapsible spoke screws before re-reeling.
- » Replace worn out parts of the re-reeling machine.

f. To avoid cut ends

- » Handling of hanks from the stage of removing from the re-reeling up to packing has to be careful such that the ends do not get hooked to articles and get cut.
- » Knot the broken yarn at re-reeling without fail.

g. To avoid stains

- » Hanks from the re-reeling until packing should not come in contact with oil grease or any other staining material.
- » Keep the re-reeling machine clean.

h. To avoid double ends

- » Knot the broken thread while reeling immediately during re-reeling.
- » Avoid skeining and lacing defects.
- » Lacing has to be done with a cotton thread at 6 points and each lacing thread has to pass through the hank at 5 points.
- » Ensure proper supervision to see that the weight of the hanks is quite uniform. More variation in skein weight reduces the quality.
- » Knot the broken yarn at re-reeling without fail.

i. To improve the colour of silk

- » Separate out melt and stained cocoons.
- » Use soft water for reeling.
- » Avoid cooking / brushing bath getting dirty.

j. For uniform softness of silk

- » Use soft water for reeling.
- » Avoid water with iron content in it.
- » Do not raise the drying temperature at re-reeling to more than 45°C.

k. To avoid winding breaks in the skein

- » To reel with the determined number of cocoons per end.

- » To use “turkey red oil” of 2% in the small reels soaking/permeation water.
- » To knot the broken threads during re-reeling without fail.
- » Uniform drying of hanks.
- » Temperature during re-reeling should not be less than 45°C.
- » Re-reeling speed should not exceed 150 rpm.
- » If embers dry the silk, the wire mesh has to be fixed between the reel and the tray containing embers.
- » To see that the “diamond shape” is obtained in the hanks surface.
- » From the removal of hanks from re-reeling until packing, care has to be taken to see that the yarn in the hank does not get hooked to any object and break.
- » Supervision at re-reeling.

l. To improve the evenness and neatness of silk yarn

- » Hot air dry the cocoons.
- » Do not use water with high pH and alkalinity.
- » Do not over boil the cocoons.
- » After brushing, the cocoon ends has to be cleared before taking for reeling.
- » Maintain 10 cm of croissure.
- » Regulate the reel speed, avoid very slow reeling speed.

m. To improve cleanness of silk yarn

- » Use good quality cocoon for reeling.
- » Adopt hot air method for stifling.
- » Separate out defective cocoons compulsorily.
- » Do not over boil the cocoons.
- » Reeling bath temperature should not exceed 40°C.
- » Use appropriate quality water for reeling.

- » Use proper button, according to the denier of the yarn reeled.
- » Maintain croissure length of 10 cm.
- » The free ends of the knotted portion should be clipped off to 2mm length.

n. To improve the evenness and neatness of silk yarn

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- » Do not use water with high pH and alkalinity.
- » Do not over boil the cocoons.
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- » Use appropriate quality water for reeling.
- » Use proper button, according to the denier of the yarn reeled.
- » Maintain croissure length of 10 cm.
- » The free ends of the knotted portion should be clipped off to 2mm length.

p. To improve tenacity and elongation

- » Do not use water with high hardness.
- » Maintain reeling bath temperature at about 40°C.
- » Maintain free rotation of croissure pulley.

- » Avoid using buttons with smaller holes.
- » Avoid high speed at reeling. The reeling speed should not exceed 150 rpm.

q. To improve cohesion characteristics of raw silk

- » Maintain croissure length of 10 cm.
- » Water should be soft.
- » Maintain reeling bath temperature at about 40°C.
- » Silk is a protenacious nature of fibroin and sericin has its own properties due to its amino acid contents, which undergo many reactions with different substances under varied conditions.
- » The sole objective of raw silk testing and grading is to assess the quality of raw silk which in turn is helpful in establishing a standard for fair and equitable transactions of raw silk.
- » Raw silk testing includes visual tests, mechanical tests (winding, size, evenness, cleanness, neatness, tenacity and elongation and cohesion) and other tests (conditioned weight, boil off and exfoliation tests).
- » The raw silk is graded (classified) as per ISA (International) and BIS (National) into three categories (Class I, II and III) according to the size of the yarn.
- » Based on the information furnished by the testing and grading of raw silk yarn, tips / suggestions are provided to improve the quality of raw silk yarn for the betterment of silk industry.

4.3 Economic Importance: By-Product and Utilization of Mulberry Silkworm, Pupae, Moths and Litter Used as Compost

Introduction

Sericulture is an agro-based industry which involves the raising of food plant for silkworm, rearing of silkworm for the production of cocoons, reeling and spinning of cocoon for production of yarn etc. for value added benefits such as processing and weaving. Sericulture is a part time family occupation mainly for the below poverty line poor people. Silk is an animal protein secreted by the fifth instar larvae for spinning the cocoon. This cocoon acts as a protective covering of delicate caterpillar to pass the pupal stage inside it and metamorphosis into an adult moth.

By product of Sericulture involves 3 different activities:

- 1. Moriculture:** The cultivation of mulberry
- 2. Rearing of the silk worm**
- 3. Reeling of cocoon to produce raw silk**

These different aspects are very much associated with each other as one depends on the other. These aspects leave some waste products or by-products at every level and these can be utilized in many ways. When the process of making one thing result in a second product and that second thing is called bi-products.

Classification of Bi-Products

According to their generation, the by-products are classified as follows:

- a. By-Product of moriculture:** Excess of pruned leaves can be used as cattle feed, manure or mulches for the mulberry garden are as fuel. Excess of pruned branches can be used as a fuel and rejected plants can be used as raw material for paper pulp industry.
- b. By-Product of silkworm rearing:** Silkworm litter, pierced cocoon, cut cocoons, floss, double cocoon, flimsy cocoon, stained/urinated cocoons.
- c. By-Product of reeling and further processing of silk:** Cooking waste, reeling waste, palade layer, half reeled cocoons, pupae, charkha waste, re-reeling waste, twisted waste.

By- Product of Cocoon

» Cocoon

Cocoon is a protective covering of Silkworm which is used as a raw material for raw silk fabrics. Cocoon is used for making various by- products.

The various by-products of cocoon are;

1. Pierced cocoon
2. Cut cocoon
3. Flossy cocoon
4. Double cocoon
5. Flimsy cocoon
6. Stained cocoons/ Urinated cocoons.

These defective cocoons are sorted out prior to cooking and can be reeled upon charkha.

» **Utilization**

1. Silkworm cocoon acts as a perfect face cleaner.
2. Led flower light /led branch light (silkworm cocoon branch light).
3. Cocoon in craft.
4. Colored cocoon.

a. Silkworm cocoon acts as a perfect natural face cleaner:

- » Silk is purest and with the protein which closest to skin all kinds of amino acids.
- » The silk protein can make skin more beautiful and eliminates the dark skin spots.
- » It can also cure the skin disease.
- » Cocoon is also used as a face cleaner.

b. Coloured cocoon:

- » Colour cocoon made by the colour food for silkworms.
- » This technology is only in China in the world.
- » These cocoons are also used for making various crafts.

c. Cocoon in crafts:

- » Cocoon can be processed into various crafts. Cocoon craft include earring, bouquet, bracelets, and cocoon flower etc.

By-Product of Pupae

- » Pupae are a non motile and non feeding stage.
- » The larval organ is degenerated and adult differentiated during this stages. Except those that are allow for reproductive purpose the rest are a waste as far as sericulture industry.

Utilization:

1. As a compost

2. As a food
3. Silkworm pupae powdered
4. As a poultry feed
5. Pupae oil
6. Pharmaceutical and bio-medical uses.

1. As a compost:

When pupae in the cocoon get died we can use these as compost.

2. As a food:

In some part of the India, China, Japan and Thailand etc. Pupae are recorded as delicious food as it contains water, fat, protein and glycogen etc. in its body composition and also a great source of essential fatty acid. This is the traditional food of Vietnamese people. It is a tasty food for tribal in some parts of Northern Eastern like some parts of Assam, Meghalaya, Mizoram and Manipur.

3. Silkworm pupae powder:

- » Silkworm pupae powder produced through dehydration and rapid drying method.
- » It is mainly used as a fodder for fishes and pigs.
- » Silkworm pupae powder has high content of crude fat which is over 22%. It also has a high content of crude protein, among them chitin, nitrogen is about 4%.
- » Pupa powdered has low content of calcium and phosphorus, but it is rich in vitamin, especially Riboflavin.

Table 45: Composition of pupae

S. No.	Composition	Percentage
1	Water	6.4%
2	Fat	15.0%
3	Protein	60.77%
4	Glycogen	5.78%
5	Chitin	4.6%
6	Ashes	2.7%
7	Others	3.72%

4. As poultry feed:

- » Silk worm pupae meal is a valuable protein sources that can be used in poultry feeding, as it has high contents of nutrients and energy.
- » Silkworm pupae are used to feed poultry.

5. Pupae oil:

- » Oil is extracted from dead pupae, this is used in soap industry. After extraction of oil the remaining cake is used for poultry feed. Silkworm pupae oil has important role in lowering blood sugar.

6. Pharmaceutical and bio-medical uses:

- » The pupa protein chitin, fibroin, serrapeptidase, glucose mine are latent precursors of post surgical, anti-inflammatory, antibacterial, neurological, ophthalmic, blood pressure, cardiac and diabetics medicines and for preparation of vitamin A, E and K.
- » The chitin a component of pupa skin used in post operational treatments because of its usability, greater pain relief and fastens healing of wounds. (Katti *et al.*, 1996).
- » Chitin found as antimicrobial agent against *staphylococcus aureus*, *Aspergillus niger* etc.

By-product utilization and economic importance of mulberry silkworm moth:

1. Male silkworm moth is used in the preparation of wine.
2. The liquid extract from the moth can be used to treat impotence, abnormal menstruation and menopausal symptoms.
3. They are used to prepare pharmaceutical product for curing trauma and to strengthen the masculine function.
4. As compost material.
5. Silkworm moth oil to obtain textile dyes and soaps.
6. As an animal feed.

By-product utilization and economic importance of mulberry silkworm litter:

In adopting any technology it is important to consider the waste utilization aspect so that better returns are obtained and the pollution of the environment by waste is minimized. In sericulture industry the waste from rearing trays, i.e. the silkworm litter, is available in large

quantities. The present study has shown that silkworm litter could be used as a nitrogen source in replacing chemical fertilizers for vegetable crop production and as a substrate for mushroom cultivation.

4.4 Silk Reeling: Factors to be Considered Before Setting up of Silk Reeling; Throwing, Weaving, Dying, Printing, Dyes used in Printing

Introduction

Silk reeling is a cottage industry in India. The un-winding of the silk filament and combining a number of filaments in to one yarn is called “reeling”. However, only the mulberry cocoon has a continuous silk filament and reeling is done only for mulberry cocoons. In the case of non-mulberry cocoons, due to the absence of continuous filament, hardness of shell etc., the yarn is usually spun. The composition of a mulberry cocoons shell is given below:

- » Fibroin 72%
- » Sericin 19-28 %
- » Fat and wax 0.5-1%
- » Colouring matter and ash 1-1 %

The cocoons are sold by the farmers in the Southern region invariably as fresh cocoons and the reelers stifle them (that is, kill the pupae) by steaming. In other parts of India like Kashmir, sun-drying of cocoons to kill and dry the pupae is still practiced. India has a variety of reeling equipments but most of them fall into 3 categories namely, charkhas, cottage basins and filatures. The country charkha is a hand operated reeling machine used in the house of the reeler. It is built with material available locally in the village, by the carpenter and blacksmith. It has a platform in which there is a basin for boiling the cocoons. After boiling the cocoons, the filament ends are identified and reed through an eccentric wheel. The reeler sits upon the platform, facing the basin and reel. This is the most primitive method of reeling and about 50% of the raw silk in India is reeled on such country charkha. In West Bengal, the country charkha is known as “Ghai”. After the Second World War, the cottage basin reeling machine was developed on the pattern of Japanese multi-end machine.

The cottage basin has small reels over head and separate equipment for re-reeling. Basically, the cottage basin consists of three separate parts namely, the cooking unit, the reel bench and the reel box. Each filature with 2400 ends imported from South Korea and Japan has been installed in Karnataka. Another similar filature is being installed in the private sector in Andhra Pradesh. About 50% of the total mulberry silk is produced on 22000 charkhas, 40% on 7000 cottage basins and 10% of the total mulberry silk in India.

Productivity of charkhas and basins is low both quantitatively and qualitatively. Because of the lesser filament length and lower reelability, the renditta is 9 to 11. The word 'renditta' means, the number of kilograms of fresh cocoons required to render one kilogram of raw silk. Thus in India, 9 kgs of the comparatively better quality of fresh cocoons results in one kg of raw silk when it is reeled on charkhas or cottage basins or multi-end reeling machines. In the case of Japan, only 5kgs of cocoons are required to produce 1 kg of raw silk. However, the quality of cocoons available in India, especially in southern States has improved as is evident from the fact that about 15 years ago more than 13 kgs of cocoons were required to produce 1 kgs of raw silk in the same equipment. It has now come down to 9 and in some cases to 8 also. Due to the decentralised and dispersed nature of silk reeling, for a number of years to come the primitive charkha system will continue before gradually giving way to cottage basins and multi-end reeling machines. The transition will be slow because, the lower quality of cocoons can be reeled only on the charkhas without much wastage. However, the quality of the charkha reeled raw silk is poorer compared to the cottage basin and multi-end reeling machines. Since charkha will continue for some more years, the Central Silk Board has made certain improvements in the charkha reeling design. This improved charkha will enable the reeler to get a higher quality of raw silk from the same kind of cocoons as compared to the traditional charkha. However, cottage basins have come to occupy about 40% of reeling.

Similarly, the improved machines namely, the automatic and the multi-end reeling machines with individual brake devices will continue to take a larger share in the reeling machinery, though slowly.

1. Silk reeling

The process extract silk from cocoon is called reeling, one cocoon can reel out about 1000 meter long silk, but it only 50% weight of the cocoon, if you want to know how cocoon be composited, please refer the structure of cocoon.



Figure 75: Hand Reel



Figure 76: Machine Reel

2. Silk throwing

Raw silk is invariably twisted in small factories except the raw silk produced in Kashmir and parts of West Bengal. Twisted yarn is used in both handlooms and powerlooms. There are about 2 lakh spindles for twisting in India. This is highly labour-intensive.

3. Silk weaving

Indian silk is essentially woven on handlooms. About 65% of the Indian silk is woven on handlooms and 30% on traditional powerlooms. The powerlooms are also organised on a small scale, cottage industry pattern. The modern silk weaving factories having better handlooms may account for about 5% of the silk productions. There are about 182000 silk handlooms and 31000 silk powerlooms in India.

There is one notable characteristic in handlooms. The inferior quality silk reeled on charkha reeling machines are suited to the slow speed of handlooms and technique of manual controls of the weavers. The better quality of coons reeled in cottage basins and multi-end reeling machines resulting in better quality of raw silk is used in power looms. However, the handloom fabrics in India, inspite of their defects, are known for their texture, colours and designs. Most of the silk handlooms are under the control of master weavers who supply silk yarn to the actual weavers and make payment on a piece rate basis

There are different routes for making fabrics but the most well known fabric form is that of the woven fabric which is made by interlacement of the warp yarn with the weft yarn at right angles to one-another. The warp threads lie along the length of the fabric (also called ends) while the weft threads (also called picks) run across the fabric, i.e. along its width.



Figure 77: Hand Weave

The process of weaving

A woven fabric is produced on a machine called a loom. The starting point for making a fabric is to get the warp beam (which is a sheet-like assembly of parallel yarns wound on a roll) ready for transfer to the loom. Though the various parts of a loom and their functions will be described later, a schematic sketch of the loom with the warp beam located at the backside of the loom is shown in Fig. 78 for the sake of clarity. The path of the warp sheet on the loom is worth noting. The actual yarn interlacement goes on in the front part of the loom and the woven cloth is then wound on the cloth roll. At this stage it would be instructive to understand how the warp beam is filled with yarn. To do this the dimensions of the cloth to be made must be known. Suppose 400 metres long cloth with 2400 threads width-wise is to be produced. Also suppose that the creel stand, which is installed for making the warp beam, has provision for mounting 200 bobbins at a time. So, the warp will be made by winding 200 yarns (of 400 metre length) in the form of a sheet on the warp beam. Note that the process will have to be repeated 12 times to complete the warp beam.

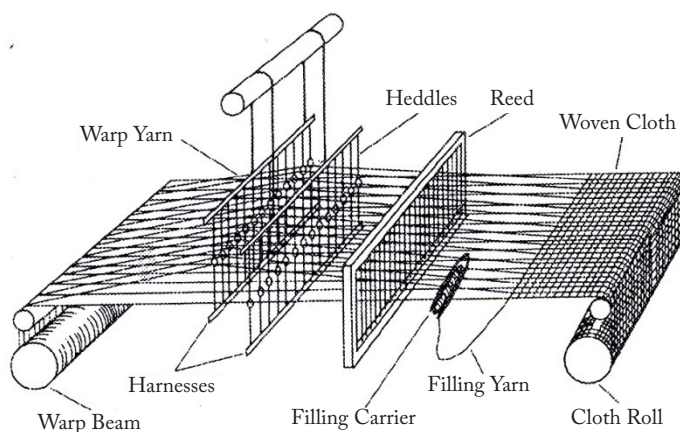


Figure 78: Process of Interlacement or weaving

After working out the details about the warp beam as given above, the empty warp bobbins are filled with the warp yarns using a winding machine. The filled bobbins are then mounted on the creel stand. Individual yarns from each bobbin are taken out and led collectively towards the warp beam in the form of a planar sheet and a 400 metre long, 200 yarn wide section of the warp wound on a part of the beam. By repeating these 12 times, the warp beam is completely filled and is ready for transfer to the loom. Before doing this, the normal industrial practice is to apply size to the warp yarns to impart cohesion to the yarns so that they run smoothly during production. The weaving process is described with the help of Figures 78 and 79.

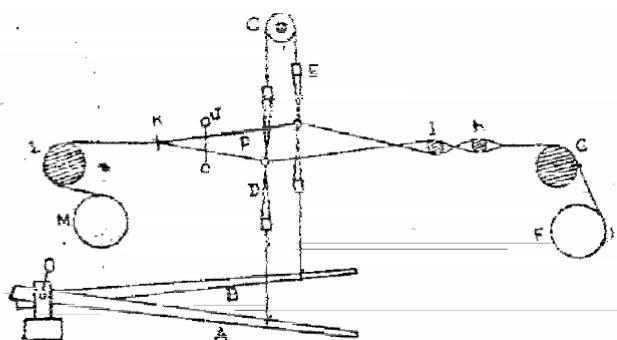


Figure 79: Line diagram of an open warp

A. Treadle (Pedal)	D. Heald	G. Back Rest	J. Reed	M. Cloth beam
B. Treadle (Pedal)	E. Heald	H. Lease Rod	K. Cloth Fell	N. Fulcrum
C. Top Pulley	F. Warp beam	I. Lease Rod	L. Front Rest	O. Shed

To begin with, the filled warp beam is transferred to position F (Fig. 79) and the warp is taken over the back rest (G) and alternately over and under the lease rods H and L, through the eyes of the healds (also called heddles) D & E. The healds are mounted in a heald frame (also called harness). The warp yarns are then guided through the dents of the reed J (which is like a comb) to the fell of the cloth, K (which is up to the last pick or weft in the cloth which has been put in place by the reed). Then the warp is taken over the front rest L (Fig. 79) onto the cloth beam M. The pedals A and B (also called treadles) fulcrumed at O, govern the up and down movement of the healds to form an opening by splitting the warp into two layers, one going up and the other down, through which the weft yarn can be inserted. When pedal A is pressed down, the heald D connected with it by cord, forms the lower layer of the opening and causes the heald E to form the upper layer, thus creating what is known as a shed with the help of the top pulley C.

After insertion of the weft thread (called a pick), the shed is closed and a second shed is formed for the second pick to be inserted by pressing down the treadle B. By alternately

pressing down the two treadles A and B, a plain weave (described later) is produced.

The large numbers of healds, which are made either from cords or from metallic strips, are held in a frame and the total assembly (including the heald shafts) is called harness. For different weave types, the number of harnesses varies considerably, the minimum number being 2 for plain weave but can go to a much larger number (a maximum of 40 harnesses is mentioned in the literature).

Fabric manufacture involves three primary and two secondary motions.

The primary motions are:

- i. **Shedding:** This is the process of splitting the warp sheet into two parts, with the help of heald shafts. Each shaft is provided with a group of healds. Each heald consists of a metallic wire provided with an eye (heald eye) through which a warp yarn is drawn. As per the weaving design repeat, we know how to draw the warp yarns in two, three or five heald shafts, subject to the lifting plan. With the movement of heald shaft, the warp yarns attached to each shaft will also have up and down movement, thereby dividing the warp sheet into two layers. The opening so formed is a shed.
- ii. **Picking:** This is a process of laying the weft yarn across with the help of a shuttle inside the shed.
- iii. **Beating:** In this process, a comb (known as Reed) carries the weft yarn, drawn in the shed and places it along with the last weft, also known as the 'fell of the cloth'. The reed is fitted in a frame the assembly is known as a sley, sometimes also referred to as a batten.

The secondary motions are:

- iv. **Let off:** This is a release mechanism attached to the weaver's beam, which operates and controls the release of warp yarn from the beam.

Take up: A chain of wheels regulates the picking up of the cloth and keeps wrapping up the same on a cloth roll, through a roll, known as Emery Roll.

1. Basic weave

During weaving the warp and the weft can be interlaced in a wide variety of ways to give different weave types. A weave may be characterized by its repeat unit. Basic weaves are those that require a minimum number of warp and weft yarns to constitute their repeat units, e.g. plain weave needs just 2 warp and 2 weft yarns. Twill weave needs 3 warp and 3 weft yarns while satin weave needs a minimum of 5 warp and 5 weft yarns. A large number of weaves can be derived from these three primary or basic weaves - the latter will be considered in some detail now.

2. Plain weave

Plain weave is the simplest form of interlacing (Fig. 80) and can be generated with only two harnesses. One harness controls the movement of even numbered yarns in the warp sheet and the other harness controls the movement of odd-numbered yarns. To begin with, the first harness lifts up the even- numbered yarns and the shuttle moves to insert a weft yarn. While returning, the second harness lifts up the odd-numbered yarns and the shuttle then moves below it to insert another weft yarn. Thus in plain weave the sequence of interlacement is altered for every adjacent end and thus the structure produced looks alike on the face and back of the fabric. A schematic representation of the plain weave structure is shown in Fig. 80.

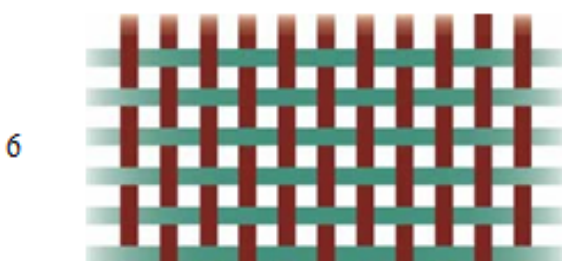


Figure 80: A schematic representation of the plain weave structure

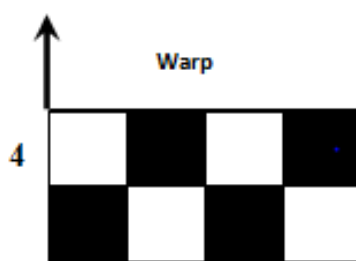


Figure 81: The longitudinal columns are considered as warp/ends and numbered as 1, 2, 3.

Such structures may also be shown graphically as in Fig. 81. In this figure the longitudinal columns are considered as warp/ends and numbered as 1, 2, 3.

1. In the same way the transverse rows are considered as weft/picks and also marked as 1, 2, 3, 4. The convention is that where the warp yarn goes up over the weft, it is marked as a black square and where the warp yarn is below the weft yarn, it is left blank (white square).

For representing “plain” weave, warp No. 1 goes above pick No. 1, so marked black, below pick No. 2, so left blank, above pick No. 3, marked black and below pick No. 4, left blank and so on.

Now warp/end 2, which is to reverse this sequence, starts interlacing from pick No. 2. It goes above pick No. 2 so marked black, below pick No. 3, so left blank, above pick No. 4, so marked black, and this continues.

In this graph, the interlacement of warp and weft represented on 2 warp ends and 2 weft picks, goes on repeatedly to form the fabric structure. This plain weave structure is very compact and perhaps the most used woven structure.

3. Twill weave

The twill weave structure requires a minimum of 3 warp/ends and 3 weft/picks to produce this weave which is distinguished by diagonal lines, as shown in Fig. 82.

The simplest twill is that created by the weft crossing over two warp yarns, then under one, the sequence being repeated in each succeeding shot (pick), but stepped over, one warp either to the left or to the right. Twills with more warps than wefts floating on the fabric's face are called warp faced; those with wefts predominating, are called weft faced.

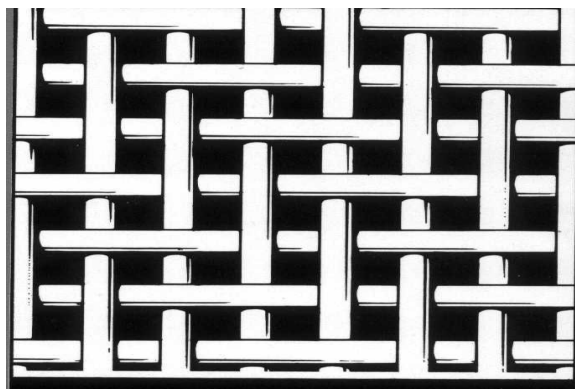


Figure 82: Twill Weave Structure

4. Satin/Sateen weave

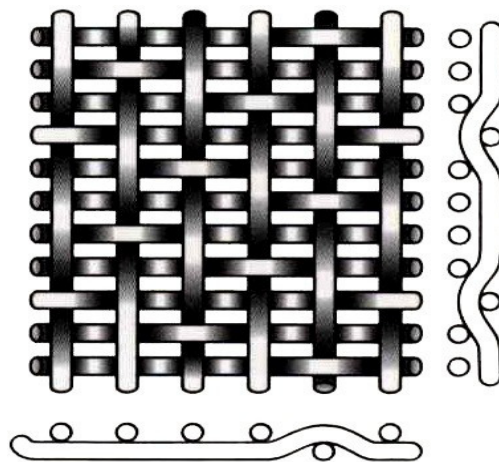


Figure 83: Sateen Weave

Satin is a cloth that typically has a glossy surface and a dull back. A satin is a warp-dominated weaving technique that forms a minimum number of interlacing in a fabric, as shown in Fig. 83.

A satin-woven fabric tends to have a high lustre due to the large number of “floats” on the fabric. Floats are “missed” interlacings, where, the warp yarn lays on top of the weft yarn, or vice versa. The floats tend to make the fabric look glossier as well as give it a smoother hand in most cases. This type of weave requires a minimum set of 5 warps and 5 wefts.

4. Dyeing and finishing

Dyeing and finishing including three main processes: refine oxidizing process, dyeing process and finishing process.

1. **Refine oxidizing process:** The silk filament composited by two ingredient, the main is silk protein, outside wrapped by sericin, the sericin mainly composed by pigments, oils, waxes and inorganic salts, these impurities will greatly affect the dyeing process, so they need to be remove before dyeing, the raw silk after refined we get white boiled-off silk.
2. **Dyeing process:** Because the main ingredient of silk is protein, so it need to be dyed in acid dyestuff or neutral dyestuff.
3. **Finishing process:** Mainly including mechanical finishing and chemical finishing, mechanical finishing to handle the wrinkle problem and breadth problem. Chemical finishing is to add some fabric softener, antistatic agent to let the silk fabric become more soft and anti-wrinkle.



Figure 84: Finishing Machine

4. **Printing:** Printing is a process for mass reproducing text and images using a master form or template. The earliest non-paper products involving printing include cylinder seals and objects such as the Cyrus Cylinder and the Cylinders of Nabonidus. The earliest known form of printing as applied to paper was woodblock printing, which appeared in China before 220 AD. Later developments in printing technology include the movable

type invented by Bi Sheng around 1040 AD and the printing press invented by Johannes Gutenberg in the 15th century. The technology of printing played a key role in the development of the Renaissance and the scientific revolution, and laid the material basis for the modern knowledge-based economy and the spread of learning to the masses.

Dyes Used in Printing

» Dye

A substance that is used to change the colour of the something. Dye is a colored substance that chemically bound to the substrate to which it is being applied. This distinguishes dyes from pigments which do not chemically bind to the material they colored.

» Textile dyeing

Textile dyeing is a process in which colored is transferred to a textile material (like fiber and yarn) to add permanent and long lasting color. It can be done by hand or by machine.

As a textile fiber has been discussed for their varied qualities and as the spinning and weaving process has been explained the qualities of durability and serviceability have been constantly stressed. When the yarn is made into fabric the interesting and intricate construction begins to add beauty of appearance as well as service ability. The various finishing process suggest additional means of enhancing the appearance of the newly formed fabric. It process to provide lasting beauty and delight to beholder by adding color to fabrics. Dyeing and printing differ in the method by which color is applied to fabrics. In the dyeing process fiber yarn or fiber is impregnated with a dye stuff .In printing a pattern or design is generally imprinted on the fabric in one or more colors by using dyes in paste form or some related means.



Figure 85: Dyes

» Selection of dye

To select the proper dye for a fiber it is necessary to know which dyes have an affinity for the vegetables, animal or made fibers. In general dyes used for cotton and linen may be used for rayon's, but other fibers requires different dyes. When a dye colour fabrics directly with one operation of impregnation, without the aid on fixing agent, the dye is said to be a direct dye for the fiber. Direct dyes are easiest to produce the simplest to apply, and the cheapest in their own limitations. One of these is the degree of color fastness.

Fastness of color refers to its ability to remain unchanged. Different dyes of different colors have different degree of fastness to various conditions. For example a color that may have good fastness to laundering may have poor fastness to light. Color fastness may be affected by such factors as perspiration, dry cleaning, bleach, salt, water swimming pool additives atmospheric gases, or air pollutants. Also certain dyes may bleed or, run when wet and may cause discoloration of other fabrics. Some dyes may crock or rub off, due to the friction of water.

Consequently, selection of the proper dye is crucial to its ultimate use. Fastness of light is important in draperies, e.g., as they must stand strong light daily but do not needs to be wash frequently .Fastness to washing is important in dress fabrics and household linens because they must undergo to frequent washings. Therefore, both the kind of fiber be dyed and the intended use for the fabric should be considered. Once a colour has been selected, it essential that its formulation be kept consistent. Each batch that is dyed must have its dye lot number. Since variation can occur in such factor as chemical concentration, fibred structure, water content, or temperature and causes a slight change in color, each dye lot will be slightly different. Matching apparently the same colour between two different pieces may become a problem. It is therefore important to use material from the same dye lot when piecing together such items as apparel or drapery. Sometime a color may be formulated by a dyer to mach an existing colors on fabrics. When two or more types of fabrics are dyed, particularly by different dyers, the colors may appear to match in one (e.g., daylight) but will not match in one light (e.g., incandescent). Such as conditions is known as metamerism, or color flare. Prior testing should be made on samples on samples to avoid this difficulty.

Selection of Dyeing Method

Textile may be dyed at any stage of their development from fiber into fabric or certain garments by the following methods:

- a. Stock dyeing, in the fibre stage.
- b. Top dyeing, in the combed wool sliver stage.

- c. Yarn dyeing after the fiber has been spun into yarn.
 - d. Piece dyeing after the yarn has been constructed into fabric.
 - e. Solution pigmenting of dope dyeing, before a manmade fibre is extruded through the spinnerets.
 - f. Garment dyeing after certain kinds of apparel are knitted.
1. **Stock dyeing:** Stock dyeing refers to dyeing a staple fiber before it is spun. In stock dyeing which is most effective and expensive method dyeing the color is well penetrated into the fibers and does not crock readily. Stock dyed fiber does not spin as readily as undyed fiber because it loses some of its flexibility, but lubricants added in the final rinsing overcome most of this difficulty.

Woolen are often stock dyed. Stock dyeing process mixture effects and colour blends, of which oxford suiting and tweed homespun are example.

2. **Top dyeing:** One step nearer to the finished yarn than stock dyeing is what is called top dyeing in the worsted industry. Top is wool that has been combed to take out the short fibers then delivered from the combs in a rope.
3. **Yarn Dyeing:** When dyeing is done after the fiber has been spun into yarn, it is described as yarn dyeing.
4. **Skein dyeing:** Yarn may be prepared in skein or hank, form and then dyed. The loose arrangement of the yarn allows for excellent dye penetration.
5. **Package dyeing:** Yarn wound on spools, cones, similar unit and then dyed is referred to as package dyed yarn.
6. **Piece dyeing:** The great bulk of dyed fabric on the market is dyed in the pieces. This method gives manufactures maximum flexibility for their inventories to meet larger small demands for a giving color as fashion require.
7. **Union dyeing:** This process of dyeing piece goods made up of different fibers or yarns in one color may be readily accomplished. Although different fibers may require different dyes to obtain the same color this may be done by putting the appropriate color dye that is specific to each type of fiber into one dye bath.
8. **Back dyeing:** Long length of cloth that are to be dyed on a continues process are very often back dyed or box dyed by passing by passing the fabric in tension free rope from through the dye bath. The rope of cloth moves over a rail on to a reel which immerses it into the dye and then draws the fabric up and forward to the front of the machine.

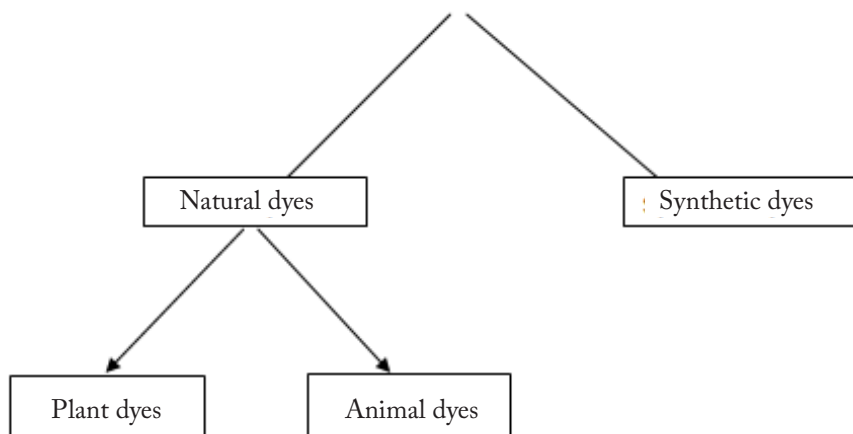
The process is repeated as long as necessary to dye the material uniformly to the desired intensity of color. Much of the original softness and fullness of the fabric is retained with back dyeing and it is therefore widely used for woolen and worsted woven goods and knitted fabrics.

9. **Jet dyeing:** Fabric may be jet dyed by placing it in a heated tube or column where jets of dye solution are forced through it at pressure up to 300 pounds per jet. The dye is continuously recirculated as the cloth is moved along the tube at speeds up to 300 yards per minute. The fluid moves faster than the cloth floats through the tube without touching the walls. The method is not only fast but also very thorough and crease and rope marks may be avoided.
10. **Chip dyeing:** Special dye may be added to the polymer for the production of such fibers as nylons prior to melt spinning of the chips. The dye stuffs are resistant to the reducing action of the polymer under high temperature. Such dyes will not fade, crock or run.
11. **Garment dyeing:** Certain kinds of non tailored apparel such as hosiery, pantyhose and sweaters can be dyed as completed garment because they are each made of a single component and will not be readily distorted. A number of garments are loosely packed into a large nylon net bag. The bags are then put into a paddle dyer which is a tub with a motor driven paddle that agitates the dye bath. Garment is an economical method and is used when practical. It also reduces the risk of building an inventory that could be affected.

Different Equipments Used for Dyeing

1. **Winch:** In this machine dye bath is put in a larger vat. Ropes of fabrics are sewn into a continuous circle. The drums pull these ropes from the dye bath at one side and drop them into the bath on the other side. The machine consumes a lot of water and can dye only at temperature below 100°C. This system is suitable for soft cotton and fully wools.
2. **Jet dyer:** Jet dyer is improved equipment used for rope dyeing. This is closed equipment through which the fabrics in rope form pass along with the dye bath. It can be pressurized and heated at 15 °C for processing. It consumes less water.
3. **Beam dyer:** Beam dyer is used for dyeing open width with fabric as it is not possible to dye all the fabric in rope form. The fabric is wound evenly and loosely on a perforated beam to ensure complete and uniform penetration of dye. The equipment can be used for dyeing at standard atmospheric as well as high temperature conditions.

CLASSIFICATION OF DYES



a. Natural dye

Primitive people obtained dye forms from flowers, nuts, berries and other form of vegetable and plant life, as well as from mineral and animal sources. These sources have provided such natural dyes throughout civilization. They are no longer used in quantity by the dyeing industry, but they are still used in oriental countries to a certain extent for rug dyeing and in many parts of the world formative handicraft. The principle vegetable dyes are fustic, sumac, catechuorcutch, mudder, heena, saffron, logwood, alizarin and indigo. Animal dyes such as cochineal, sepia, lac and *Tyrian* purple, are obtained from species of fish and small insects. Minerals provide such dyes are blue, chrome and iron buff.

1. **Indigo:** Indigo dye obtained from madder plant. The plant is dug up, the roots are washed and dried and use into the powder form. This dye is dark blue in colour that was considered brilliant and exotic.

This is the most ancient natural dye used by man in textiles. Indigo is about 2-3 feet long plant, cultivated on thousands of acres of land in India. The whole plant is used for extraction of dye and is supplied in powder form. This gives deep blue colour. This is the only natural dye which falls under vat category of dyes.

2. **Logwood dye:** Logwood (*Haematoxylum campechianum*) Log wood main use is for dyeing textile and leather but it is also used to produce the stain *haematoxilin* for microscopic slides. Logwood is an easy dye to use, producing violet, grey and black colour.

Log wood is a spiny tropical American tree, largely found in the Yucatan Peninsula of Mexioco. The extract of this wood is purplish red dye derived from processing the darkest heartwood. Logwood extract is used to make *Hematine* and *beamatoxilyn*.

3. **Pomegranate rind dye:** This dye is obtained from fruit of *Punica granatum* the colour of this dye is yellow. The main coloring agent in the pomegranate peel is *granatonine*.
 - » Soak the pomegranate rind in hot water overnight.
 - » Simmer the rind for an hour the next day.
 - » Let it cool down, stain the rind and save the liquid.
 - » Add your mordant fiber to the dye pot.
 - » Let the fiber cool in the dye bath.
4. **Persian berries dye:** Persian berries come from the Avignon buckthorn (*Rhamnus saxatilis*) and are also known as Avignon berries. They have been used as a natural dye for hundreds of years. Persian berry is a strong extract and 20 grams of persian berry extract dye 100 gram hanks of blue faced Leicester super wash wool to a very dark golden yellow and a medium yellow color respectively, depending on water quality and other factors.
5. **Onion dye:** An onion skin dye can be your simplest point into the world of natural dying. This dye is obtained from onion skin. The colour of this dye is yellow to copper red. Place the onion skins into a saucepan or pot and cover with water generously. Bring to the boil and simmer for approximately 30-45 minutes. Once you have a lovely color in your dye pot, strain the skin off and discard them.
6. **Cochineal dye:** This dye is obtained from animal. It is a brilliant red dye produced from insect living on cactus plant (*Coccus cacti*). The female cochineal insect is dried in sun and then ground the dried bodies to produce a rich powder, when mixed with water; powder produces a deep vibrant red colour.
7. **Tyrian purple dye:** This dye is obtained from shell-fishes, snails etc. The colour of this dye is green, red and deep purple. It was first produced by the Phoenician city of Tyre in the Bronze age.
8. **Lac dye:** It does not have the brilliance of cochineal red dye, like wine. Lac is the scarlet resinous secretion of a number of species of lac insects, of which the most commonly cultivated species is *Kerria laca*. The resinous secretion which is known as stick lac contains about 45% wax and 1% water soluble coloring material known as lac dye.
9. **Sepia dye:** Sepia dye is a reddish brown colour named after the rich brown pigment derived from the ink sac of the common cuttlefish sepia. Sepia dye is mostly used in photography which changes the appearance of black and white prints to brown.

Most photographic software programs and many digital cameras include a sepia tone to mimic the appearance of sepia-toned prints.

Table 46: Some of the various natural dyes

Natural dyes	Source	Colour obtained
Plant sources		
Indigo	Stems and foliage of <i>Indigofera tinctoria</i>	Rich blue
Alizarin	Roots of madder plant	Red
Logwood	Vegetable dye	Black
Annatto	Fermented fruit of <i>Bixa orellana</i>	Bright orange
Pomegranate rind	Fruit of <i>Punica granatum</i>	Yellow
Myrobalam	<i>Terminalia chebula</i>	Red and brown colour
Catechu/cutch	Obtained from wood and pods of species of Acacia, Mimosa, Terra japonica	Yellow-orange to brownish-black colour
Fustic	Species of sumac	Yellow, brown, red hues
Balsam	From flower of balsamina	Orange, Yellow to brown
Harshinagar	From flowers that come under family Oleaceae	Yellow and orange
Kamala	Pods for tree belonging to Euphorbiaceae	Orange-red
Animal source		
Cochineal dye	Dead bodies of female insects, <i>coccus cacti</i> .	Crimson, sarlet and orange.
Tyrian purple	Shell-fishes, snails.	Green, red and deep purple.

Table 47: Some of the various synthetic dyes

Synthetic dyes	Fibers dyed	Characteristics
Acid dyes (anionic) e.g., mentanil yellow, picric acid, acid magenta, acid violet.	Wool, silk, nylon.	Bright colors, poor fastness to washing.
Basic dyes(cationic) e.g., malachite green A, Ethyl, violet, rhodamine	Acrylics	Bright colors on acrylics.
Direct dyes	Cellulose fibers	Cheapest, easy to apply, poor fastness to washing good fastness to light
Vat dyes	Cotton, supports wear, prints, drapery fabrics	Good light and wash fastness.
Sulphar dyes	Cotton, heavy work clothes, sulphur black is widely used.	Moderate fastness to light and wash, sensitive to chlorine bleach.
Disperse dyes	Acetate and other synthetic fibers	Moderate fastness to light and washing.
Mordant dyes e.g. alizarin orange A, meta chrome brown BR	Wool, silk, nylon, rayon.	Good light and wash fastness, dull colors.
Reactive dyes	Cotton, wool, silk, nylon.	Excellent fastness to light, crocking dry cleaning and fume fading, affected by fluorine bleach, bright colours.

b. Synthetic dye

Synthetic dye is also known as chemical dyes. Synthetic dyes are manufactured from organic molecules. Synthetic dyes are made up of chemical compounds that can be harmful to humans, especially those who work in their production. Some of the chemicals are mercury, lead, chromium, copper, sodium chloride and benzene etc.

Although synthetic dyes were first derived from coal tar in 1956. They were not developed to any great extent until world war IST when the supply of imported synthetic dye was cut off. Since then each country has built up a dye industry that is unsure passed. Innumerable dye compound made from coal tar have not supplanted natural dyes. These synthetic dyes

are constantly being improved as to beauty of colour is an important factor in consumer finished good durability of colour depends on:

1. Selection of proper dye the fiber to be dyed.
2. Selection of the method of dyeing the fiber yarn or fabric.

The synthetic dye is classified into several classes. The classification is based upon the particular type of chemical composition of the dye and the method of its application.

1. Basic (Cationic) dyes

The first coal tar dye was called basic dye. It was developed to give many bright shades for silk and wool. The chemical agents that bind the dye to a fibre, which otherwise has little or no affinity for dyes is known as mordant. Cationic dye is used for cotton, linen, nylon, polyesters and acrylics etc. They give good fastness and bright shade to acrylics for which they are principally used. Basic dyes are frequently used as an after treatment for fabric that has been previously dyed with acid colours.

2. Acid (Anionic) dyes

These are one of the oldest synthetic black; one of the most intense and fastest blacks available is an example of this group. Excellent browns are also available for printing. They are used primarily for cotton and can be applied with oxidizing agents and care full processing to wool, silk and acetate.

3. Azoic dye

This is the third group of direct dyes that is further identified as naphthol and repidogen types. They are quit fast to washing and vary from poor to excellent on cotton and for special purpose on nylon and acetate.

4. Disperse dye

These dyes were developed originally for dyeing acetate fibers and have since found wide use in dyeing triacetate, nylon, polyester, acrylic as well as cellulose fiber. While, there are not soluble in water.

5. Sulfur dye

Sulfur dyes first made in 1879 are used for cotton and linen. These dyes are fast to washing, light and perspiration, but they have one weakness, excessive chlorine bleaching will strip of color. Sulfur dyes are insoluble in water and must be made soluble with the aid of caustic soda and sodium sulfide.

6. Vat dye

The first synthetic vat dye was an indigo created in 1879. Vat dyes are the fastest dye for cotton, linen, and rayon. They also may be applied to wool, nylon, polyesters, and acrylics with the use of a mordant. Vat dyes are not only resistant to the strong oxidizing bleaches used in commercial laundries.

Table 48. Chemical used for silk dyeing

S. No.	Commonly used chemicals	Functions
1.	Urea	Increase the solubility of dyes control the sublimation of high temperature
2.	Lyoprint R G	Control the reduction of dyes at high temperature during steaming.
3.	Soda ash	Control the rate of reaction between dyes and cellulose or in other words it is used for fixation reactive dyes.
4.	Sodium bicarbonate	Control the rate of reaction between dyes and cellulose or in other words it is used for fixation reactive dyes.
5.	Cibaflaw pad	To increase the wettability of fabric and penetration of dyes in the fibre.
6.	Anti- migrating agent	Increase the viscosity of dying. To [protect the migration of dye under high temperature.
7.	Anti-flaming agent	Used to prevent formation of foam during stirring or during dying on one bath.
8.	Electrolyte	Decrease solubility of dyes in liquor increases affinity between dyes and fibre under moist condition.

The present scenario is focused more towards the utilization of the vast diversity of natural resources of colour pigments for their use in food materials, pharmaceuticals and textiles, in place of their synthetic counterparts. This trend is aimed at safeguarding human health as well as protecting and prolonging life on earth. Therefore, if natural dyes have to be commercialized, they need to conform to the same stringent standards of performance that are applied to synthetic dyes. It thus follows that much more research and developmental effort needs to go in this area.

SILK REELING, EXPORT AND IMPORT OF SILK, POLICIES AND COCOON CRAFTS

5.1 Comparative Economics Between Charkha, Cottage Basin and Multiend Basin

Introduction

Silkworms are reared for obtaining cocoons which form the raw material for producing raw silk. The technique of raw silk making was discovered several million years ago. The cocoons are softened using hot water and the silk filament is drawn continuously. This uniform thick and strong thread is used for the manufacturing of fine silk fabrics. Silk reeling is the final and purely commercial phase of sericulture. It is concerned with unwinding of the silk filaments of the cocoon. The term raw silk (Grege) in industry or commerce is commonly understood to denote mulberry raw silk. It is the compact untwisted and undegummed silk thread that is formed by combining the required number of silk filaments drawn from as many separate cocoons by a special technique called Reeling. This includes a series of skilled operations to transform raw material (cocoons) into a fine, continuous silk filament of great length. Unlike other aspects of sericulture, reeling needs constant attention and care, since the process of reeling the cocoon filaments break continually and reeler must properly attach fresh filaments to make a continuous filament. If not, the reeled silk results in the abrupt occurrence of thin lengths. The building in which cocoons are reeled for the production of raw silk is called a filature. It is carried with sophisticated automatic machines, to ensure production of raw silk of desired qualities. The filature concept is seen in developed countries where the raw

materials (cocoons) are of superior quality. But in other countries (where cocoon quality is not good) highly efficient multi end reeling machines with auxiliary equipment are installed and rational techniques of production are adopted. Besides these cottage industries are also found in the remote rural areas of cocoon production. These machines consist simple mechanism, simple methods of reeling. The appliances are either foot-powered or hand-driven, with simple methods of raw silk production. The cottage reeling industry has neither set patterns of organization nor standardized equipment and production techniques. But the aim of reeling in the cottage sector is always to obtain the maximum yield of raw silk from cocoons at the minimum cost of material and labour. It also produces raw silk which would satisfy all silk weavers and other pure silk industries. The importance of reeling industry is well established long ago and the demand is increasing day by day. Though it is linked with agriculture sector and industrial sector has good scope for solving unemployment directly and self employment indirectly. The various aspects of importance of reeling industry scope and limitations are discussed in this unit.

There are different reeling devices in India viz., charka, and filature consisting of cottage basin and domestic basin and Multi-end reeling basins. Charka reeling device is crude contrivance for producing silk, which has maximum mechanization and practically no gadgets. These charkas could be hand operated or motor operated. Of later, more and more charkas are being made motor operated due to increasing labour cost. The charka silk has distinct identity in the market and is generally associated with poor quality. However, a small proportion of good quality charka silk is also a reality. Charka silk is largely preferred by the handloom weavers (Shekar Prabha 1992).

The filatures have comparatively better mechanisms and basic gadgets capable of producing better quality raw silk. The filature silk with wide ranging quality is produced in reality (Gopal and Asopa, 1993). They fetch higher prices than the average price of charka silk and are purchased by handloom weavers and the best quality by the Zari manufacturers. The capacity to purchase cocoon in case of filature reelers is better than that of charka reelers. The upper end of the reeling technology has Multi-end reeling machines. In India, the automatic and semi-automatic reeling machines have been a failure in meeting the economic, productivity and quality requirements of the industry owing to its huge investment cost and serious limitation of the basic raw material viz., cocoons. Multi-end reeling machine is an improvement over the cottage basin and is the most appropriate technology that can handle the available quality of cocoons to produce gradable quality raw silk. However, the investment cost is very much on the higher side in comparison to cottage basin of domestic basin of equivalent capacity.

Reeling is carried out mainly in small units with wage labour or family labor. Wage labourers in reeling are among the poorest and substantial numbers are from disadvantaged groups. Reeling is an activity in which men, women and children are employed. However,

silk reeling is considered the most problematic of sericulture activities related to silk reeling become victims of health problems. With silk reeling being an important source of income and employment for a significant number of people in Ramanagara, the workers organize their lives around activities related to silk reeling.

Cooking and Reeling

1. Charka oven

The majority of the charka oven units use non-woody biomass fuel such as groundnut shell, paddy, husks, etc. this is the simplest mechanism for silk reeling, in which both the cooking and reeling operation are carried out in the same basin. First, the water in the basin is brought to boiling by allowing higher burning rate of the fuel. The cocoons are then cooked for few minutes, with simultaneous stirring and mixing, after the cooking is over, the temperature in the basin is reduced by adding cold water and simultaneously reducing the burning rate of the fuel cutting of the air supply by closing a damper. The manual reeling operation starts with the reeler rotating the charka by hand and the other person attending to the process of feeding the silk thread to the charka. In some units, where several charka ovens are installed under the same shed, the reel is power driven by a common shaft. After all the cocoons are reeled, the cooking operation starts by increasing the rate and the process continues. The quality of yarn produced in charka units' accounts for nearly 50% of raw silk produced in India.

Although, charkas are not made according to any specification of measurements, they are all similar in design and constructional details. Generally charka establishment installs five to six charkas and each consists of three distinct parts namely, the mud platform, distributor and reel.

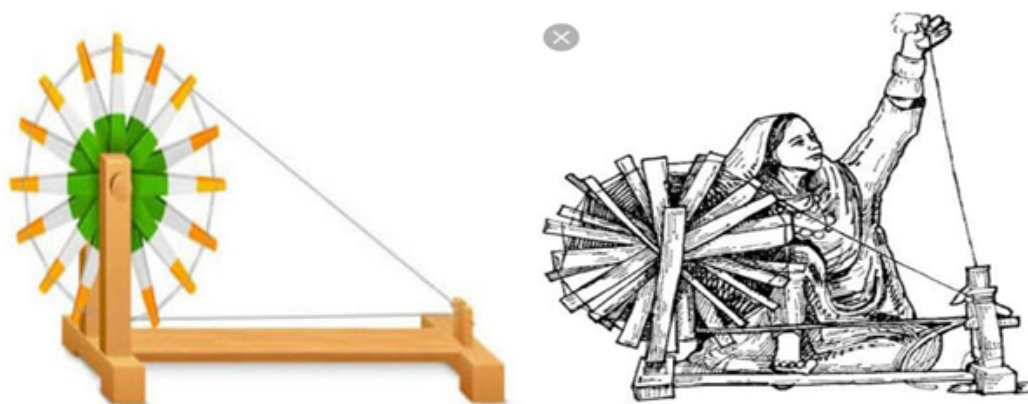


Figure 86: Gandhian charkha

2. Charka reeling

a. Mud platform

This is rectangular in shape and usually measure about 60 to 75 cm high and 90 cm wide and 120 cm long. The forepart has a built in fire place with a basin fitted over it. The other part of the platform is solid with a flat top intended for the reeler to sit and attend to the reeling operations. The basin is of thick copper sheet and is generally of circular shape measuring about 50 cm in diameter and 20 cm in depth. Occasionally, instead of a copper basin which is comparatively costly, one half of a vertically bisected earthenware pot is used. Even the use of aluminum basin is quite common. The basin is buried up to its brim in the platform with the spacious part of the basin's underside exposed to the fire place. The basin is used for both cooking and reeling operations. The fire place which is not provided with a grate or ash pit is generally built for burning firewood or dry twigs. In some places it is designed for burning paddy husk or groundnut shells. At the opposite end of the opening there is a chimney provided for the flue gases to escape.

b. Distributors

This is a simple device consisting of a crudely made eccentric wheel which in operation revolves on its vertical axis and drives the wooden traverse rod to and fro. The eccentric wheel is driven by an endless cord-belt from the reeling passing over its constricted part. The traverse rod is provided with loops of wire along its length at regular intervals. These serve as thread guides for the thread passing through onto the reel. During the reeling operation, the traverse moves briskly to and fro in front of the reel thereby distributing the thread onto the reel.

c. Reel

Only one long reel made of thick sections of seasoned wood provided for each basin. Their circumference is not standardized and ranges from 150cm to 225 cm in different charkas. It can accommodate four to five ends, the reel is rotated manually or power driven.

3. Cottage basin oven

In the cottage basin system the cooking operation and the reeling operations are carried out separately. The cocoons are first cooked in the cooking unit and then taken to the reeling basins for the reeling.



Figure 87: Cottage Basin



Figure 88: Cooking Unit

a. Cooking unit

The cooking unit consists of a masonry structure of a convenient height in which several, usually four cooking pans are embedded in rows. The basins are normally made of copper. They are 20 to 22 cm in diameter and about 20 cm in depth. The oven is well constructed with ash pit, grating and chimney for the flue gases to escape. In the path of exhaust gases a fairly large metallic water drum is embedded to serve as a hot water source to the reeling basins.

The cooking units are located a little distance away from the reeling unit to prevent the heat and smoke from causing disturbance to the reelers. The average water temperature in the cooking vessels is 87-97 °C. A handful of cocoons are taken each time and put into the cooking pans. A stick is used to brush the cocoons to separate the floss and locate the ends of the filaments. The cocoons are now ready for reeling. The whole operation takes about 1 to 2 minutes.

b. Reeling unit

The reeling unit consists of four to five reeling basins. Each basin is embedded into a table; the table tops are usually spacious and provide sufficient accommodation for keeping the necessary equipment. The reeling basin is usually made of copper. It has dimensions of about 45X 25X 7.5 cm. The average temperature of water in the reeling basin is maintained at around 40°C in order to facilitate reeling taps are provided to draw water from the hot water drum of the cooking unit.

Each basin is designed to reel from four to six ends. To facilitate easy attachment of filaments porcelain button thread guides are provided each basin. Each basin has its independent croissure frame designed for application of travellite croissure. The reels are driven by corresponding drive wheels fitted on a common transmission shaft. At one end of the transmission shaft, the traverse mechanism consisting of required gears, and at the other ends, one handle is provided. Each reel is served by a braking mechanism of simple design.

The reeled raw silk is then sent for re-reeling onto bigger reels of standard size and

weight. In another version of cottage basin, namely, the domestic system of reeling, also called the Italian system of reeling, the reeling is avoided. Instead, the silk is reeled onto a standard reel in one operation. After that the yarn is skeined and bundled to make it ready for dispatch.

c. Economic ovens

The traditional ovens (charka and cottage basin) used in silk reeling units consume lot of fuel on account of their ill designed fireplace and chimney. In many traditional cottage basin ovens use of two chimneys is common. The reason for it may be removal of smoke coming out through the fuel port opening or distributing the fire on all cooking vessels. Hence, the Central Silk Technological Research Institute, Bangalore (CSTRI) developed economic oven Aimed at reducing the fuel consumption. The first version of the economic oven could not use locally available fuel like husk and cobs are required fuel wood to be fed in pieces. Therefore it found limited acceptability despite subsidies. The factors led to the development of a new version which is multi-fuel in nature. Under the National Sericulture Programme (NSP), A Subsidy of 50% in the case of charka ovens and 30% in the case of cottage basin ovens is offered. The cost of the charkas and cottage basin is Rs. 1,120 and Rs. 6500 respectively.

Table 49: Construction material requirement for CSTRI's economic oven

Particulars	Charka oven	Cottage basin oven (4 pans)
Bricks	200 Nos.	750 Nos.
Cement	10 kg	3 bags
Sand	30 bondlies	2 cart load
Paddy husk	5 kg	—
Chimney	One (4" dia.)	One (6" dia.)
Cooking vessels (copper)	One	4 Nos.
Grating	One (6"X 6")	One (10" X 10")
MS rod (10mm dia.)	0.5 kg (10 mm)	4 kg (10 mm)
Chicken wire mesh	1 meter	4 meter
Water drum	—	120 litre
Fire box door/air door	One each	One each
Pipe fittings	—	^{3/4"} gate value, 2m GL pipe

4. Multi end reeling

The structure design of the reeling machine is made of mild iron angle and steel so the

machine helps to smooth run. The frame is set on the platform made of breaks and jacking the ceramic tiles to prevent the machine from jerking and vibration during reeling. A re-reeling unit has been incorporated with the main frame for easy re-reeling during reeling time together.

a. Reeling basin

The reeling basin is made of aluminum with an optimum dimension of 62 x 44x12 cm accommodate with five reeling ends. The number of five reelers can use twenty reeling ends at a time with four basins. The basin has been set in the machine with removable facilities so that it can easily remove as when needed. The reelers may sit or stand during reeling in front of the basin.

b. Jette boutte

Jette boutte is made of high density plastic with brass hollow pin for long durability and provided efficient mechanisms. It is located at the height of 18 cm above the reeling water level. An endless spring wire drives jette boutte to rotate easily at high speed.

c. Porcelain buttons

Porcelain buttons with appropriate holes are used in the machines and fixed to the steel clip holders, which are 8 cm height from the jette boutte rail with 2.0 gm weight each.

d. Croissure pulley

A travellette type of croissure is maintained by means of croissure pulley to facilitate smoother thread movement during reeling and also to maintain proper tension level. Its weight is 18gm each. The distance between the top and bottom croissure pulley is about 13 cm and first pulley to porcelain buttons is about 8 cm at the height of 4 cm above the buttons.

e. Traverse mechanism

A planetary traverse system is incorporated for suitable distribution of thread on the reel with cam and gear arrangements. The weight of the traverse guide is 4.0 gm and length of traverse bar is 376 cm.

f. Reel

High quality small aluminum reels with smooth surface has been used. The circumference of reels is 65 cm weighing about 640 gm.



Figure 89: Multi-end reeling



Figure 90: Cooking and Reeling in multi-end

Table 50: Comparative reeling performances of Multi-end reeling machine and cottage basin

Parameters	Season	Renditta	Raw-silk recovery (%)	Reclability (%)	Waste (%) raw material	Raw silk production/ 8hrs / 10 ends(kg)	Average quantity of cocoon used/ day/ basin (kg)
Multi-end reeling machine	S ₁	10.46	70.26	63.97	22.10	0.88	5.02
	S ₂	11.39	69.31	58.30	23.77	0.86	5.27
	S ₃	11.92	66.89	59.88	28.11	0.83	5.11
	S ₄	10.26	72.76	76.80	23.06	0.99	5.00
Mean± SD		11.01±0.74	69.80±2.22	63.24 ± 5.07	24.26±2.41	0.89±0.09	5.10±0.25
Level of significance		**	**	**	**	NS	NS
Cottage basin	S ₁	11.39	69.31	62.78	23.40	0.89	5.05
	S ₂	12.72	66.68	66.80	25.10	0.85	5.09
	S ₃	12.63	65.91	63.02	28.38	0.80	4.96
	S ₄	11.09	69.87	68.54	25.91	0.90	5.02
Mean ± SD		11.95±0.78	67.94±1.79	65.28±4.38	25.70±1.91	0.86±0.04	5.03±0.26
Level of significance		**	**	**	**	**	NS

(Source: Abdul Alim *et al.*, 2016)

The silk industry is expected to produce international quality yarn to fulfill the needs of the domestic as well as international markets. The recent multi-end basin reeling device, supposed to be better in terms of quality and efficiency at the research level, is still not extensively adopted. Hence it was attempted to evaluate the economic viability of the multi-end basin reeling technology employed in the unorganized reeling sector. The overall size of multi-end basin unit was 8.50 basins per unit and functioned on an average, 308 days in a year. The Renditta was 9 and on an average, 1.34 mandays as well as 611.25 quintals of fire wood as fuel by exploiting the forests were utilized per kg of silk production. An average of 2610.86 kg raw silk was obtained per year. The total cost of raw silk production per kg was Rs. 1319.13 of which variable cost accounted for about 95 per cent. Cocoon cost alone accounted for about 85.50 per cent of the total cost. Unauthorized deductions were made both in the government cocoon markets and in silk exchanges, which needs to be strictly supervised. Heavy investment was made on the machine. Gross returns, net returns and returns to family labour and management per kg of silk reeled were Rs. 151505.09, Rs. 185.78 and 189.91, respectively. The benefit cost ratio was 2.56. This would have been still higher, if fixed investment was moderate. (Kerutagi *et al.* 2002).

Importance of Reeling Industry

The word 'silk' spells luxury and class. Even today, no other fabric can match it in luster and elegance. The touch of silk on the fingertip evokes the very thread of history. Over the centuries it has reigned undisputed as the queen of textiles. Mankind has always loved silk. It is the yarn extruded by a small caterpillar in a continuous filament as long as nearly one and half kilometers. The sericulture industry is agro based and flourishing mostly in rural areas. More than 50 per cent of silk is reeled by a villager using country charka which forms the cottage industry. Silk provides much needed work in several developing and labour rich countries. India has no exception for this statement. More than 10 million farmers raise silk in China today. India is one of the first three silk producing countries provides employment and self-employment to more than five and half million people. Among this reeling sector is a part. Since silk is a material of limited production accounting for less than 0.2 per cent of the total world production of all textile fibres. In the group of natural fibres which comprises cotton, wool and silk, production of silk amounts for 0.3 per cent only. It is of interest to note that despite enormous increase in the production of man-made fabric in recent years of global silk production has maintained steady levels. Silk was discovered in China and the earliest authentic reference to silk is to be found in the Chronicles of Chou-King (2200 B.C.). Since then silk figured prominently in public ceremonies as a symbol of homage to the emperors and an elegant wear in festivals, marriages and important occasions. Since its discovery the importance was recognized and still the demand is increasing for this natural fibre. It is clear from the literature that silk had a prestigious place in the culture and commerce of India even in the pre-vedic times. Indian history shows clear evidences of different silk fabric use from vedic period. Further mulberry importance was evident from Ithihas and Vedas.

Uses of Silk

Generally 'silk' term speaks about mulberry silk. It is soft smooth, lustrous and holds a prestigious place among textile fibres and known as 'Queen of Textiles'. Silk is sold and exported as raw silk yarn. It is woven into fabrics by power-loom or handloom and sold directly as fabrics or as readymade garments. Article made of silk i.e., ties, scarves, soles, shawls, furnishings and carpets have always had a good ready market. Knitted materials from silk fibres i.e., socks, stocking are very costly and possesses good market. Other variety fabric materials like dupions, plain silk, deluxe, satin, chiffon, chincons, crepe, brocades are made from mulberry silk. Cozy furnishing materials are made from hand-spun mulberry silk. Reeling waste, bad cocoons are used to make spun silk fabrics. The waste silks are hand spun into matka, katan, feshua (jatan or Jatam, Jhut) and noil yarns. Articles made from waste silk also have a good export market. Among non-mulberry silks tasar silk fabrics in exotic designs are produced by handlooms. They are Gicha-noil, tasar plain, cotton-tasar blend, tasar-mulberry blend, peduncle fabric. Muga silk occupies sarees and dress material production. Eri spun silk is used for dress materials and the coarse variety for making chaddar, shawls and quilts. Trimoulters silk yarn is used as package material in pencil industry and for making talcum powder puffs. Silk is used as raw material for pre-paring sound free gears for making precision machinery. In France 22-24 denier silk is used in tyre manufacturing to have a longer life span than rubber tyres. Parachutes are made from 13-15 denier silk fiber. These parachutes were used in World War-II. Cozy and soft sky jackets, comforters and sleeping bags are also made from silk. The silk gut used in surgery for internal suturing is made from silk glands. The silk glands are dissected out and put in warm water and pulled at two ends to yield a fibre of uniform thickness. This protein is auto absorbable and need not be removed after wound healing. Silk grafts have been used successfully to replace cut arteries. Silkworm can be reared in laboratory for genetic studies. This insect was proved as a good laboratory tool for any kind of experiment. Lot of research work is under progress on different lines of biotechnology, genetics using silkworms in Japan.

Raw Silk Production

The synthetic fibres had only as short period of supremacy. Among all natural fibres silk does not produce any skin allergies. Its luster, smooth texture, its natural affinity towards dyes, its wetting properties, its thermal properties and other physical properties are unmatched in any of the other natural or manmade fibre. Keeping in view of the demand for raw silk for various uses the Government of India took certain steps but did not capture a good share in exporting. The products like ties, scarves, chadder, carpets, furnishing are exported from India. In India silk trade was started in 1670. Tipu Sultan established the Mysore Silk Industry and James Anderson introduced sericulture in the Madras Presidency. The government created Sericulture Departments in Karnataka (1911) and Madras (1919). Then formation

of Mysore Silk Wearing Factory (1932), Mysore Spun Silks (1936), The Silk Conditioning and Testing House at Mysore (1942) and Sericulture Research Station at Berhampore (1943) helped India Sericulture Industry to make rapid development. Then after World War-II Indian Silk Industry were at the high demand for manufacturing of parachute and powder bags. This downtrend created Silk Development Directorate in 1945 and organized an All India Silk Conference in 1947 and worked for the establishment of Central Silk Board (CSB) at Bangalore which was established in 1949 after the Parliamentary Act. The board is under the control of Ministry of Textiles, Govt. of India. The CSB functions to promote the Sericulture Industry in every line including the industry to meet global demands. It has established International Center for Training and Research in Tropical Sericulture (ICTRIS) in 1980. Later launched the National Sericulture Project (NSP) aided by World Bank and Swiss Development Cooperation. As a result of this project 32 silk worm seed production centers, 34 Basic seed farms and 5 cold storage units were established besides 80 Technical Service Centers and seven Demonstration-cum-Training Centres. CSB has set up four research institutes. Since then the CSB is concentrating on different angles of Sericulture especially in reeling and improved the production of raw silk.

Scope and Limitations

Reeling industry is an ideal cottage industry. More than 50 per cent of silk is reeled by a village using country Charka and contributing to cottage industry. The system of cottage reeling is well suited to rural conditions with its low initial investment, village made simple appliances, labour with a little skill. Further the government is supplying the materials needed at subsidized rates even at the very low initial expenditure. Further almost all the states have introduced different schemes for financial, technical and material assistance. Besides this Nationalised Banks, Co-operative Societies and other funding agencies are extending loan facilities for all activities of sericulture. India has the unique distinction of being the only country in the World which cultures all the known commercial varieties of silk i.e. Mulberry, Tropical and Temperate Tasar, Eri and Muga. Out of these India holds the World monopoly in the production of Muga-the Golden Yellow Silk. The sericulture industry is one of the most labour intensive sectors of the India economy coming both agriculture and industry. Its operations pro-vide means of livelihood to a large section of the population. Of which reeling industry contributes more employment as reeler, twister, weaver, hand spinners of silk waste, traders, by product collector. Further, it is turned as highly remunerative cash crop in a short span of time with minimum investment and became successful in attracting the new entrepreneurs. Among all the activities of sericulture the reeling sector gets 43% share distributed at all angles it provides whole time and part time employment to rural people of the country, majority of them belonging to economically weaker sections, Schedule Castes, Schedule Tribes as well as a divas (tribal's).

The income generating sources in sericulture are open in:

- a. Production of Reeling Cocoons
- b. Production of Raw Silk.
- c. Utilization of bye-product viz., Pupae and Silk waste

The demand for silk fabric is increasing since its invention. India is very poor producer of raw silk to meet international standards. In India raw silk production is overtaken by silk waste. India produces annually about 180 tonnes of spun silk yarn and 130 tonnes of noil yarn besides hand spun yarn. A wide range of products made of these waste silks such as dress materials and furnishings which are having considerable export demand. Keeping in view of increasing demand India has to work out for improvement of these sectors for further more employment generation as well as export business. Silk weaving is largely undertaken on handlooms which required no license. There is need for better mechanization of handlooms. On the other hand silk waste processing and production of spun silk yarn is a scheduled industry which falls under schedule 23 (4) of Industrial Development Regulation (IDR) Act, 1951 which requires a Industrial License under Ministry of Industry, Government of India, New Delhi. Silk reeling, using country charka is of low quality but it contributes more to the raw silk produce. The reasons for low quality silk in country charka are as follows;

1. No sorting of cocoons. Defective cocoons are also reeled.
2. No cocoon mixing.
3. Improper deflossing.
4. As there is no jettebout the dirt, gum spots etc., can be eliminated.

However, the charka has Tharpatti but cannot function like button or jettebout. This low quality raw silk hampers the export market. The main aim and objective of silk reeling is to export the raw silk for which reeling process is to be undertaken by technical hands on standard reeling machines. Silk reeling industry equipped with improved machines like multi-end reeling machines or automatic reeling machines have wide prospects. This aspect of sericulture is to be given proper attention to improve the reeling machines, training the technical persons to operate latest machines, production of quality cocoons to reel out on automatic and semi-automatic reeling machines. There by process of reeling as well as raw silk quality improves and also gives good foreign exchange. Country charka has to be improved by providing button. The reelers are to be given training to adopt themselves for latest machines. Reeling industry must be given priority for loans by Central Silk Board (CSB), State Government departments through their directorate, NABARD, Co-operative Banks, Nationalised and Grameena Banks. Training is to be imparted by State and Central

Government Schemes, such as TRISEM, D.R.D.A., and Nehru Yuva Kendras. According to the latest statistics available on income per day is Rs.45.16 in the reeling machines compared with Rs. 10.36 in country charka. Similarly income that comes by selling raw reeled on country charka is very less when compared to silk reeled out on improved or semi-automatic reeling machines. In India semi-automatic and automatic reeling machines are confined to certain states and practically they are not being used because the green cocoons which are available cannot suit to feed such machines. Thus lot of importance is to be given to evolve new races to suit the latest equipment so as to get good cash returns. Reeling industry needs lot of technical persons which is now lacking. Therefore training programmes are to be launched to benefit the reeler.

5.2 Comparative Economics Between Handloom and Powerloom

Introduction

Textile sector in India is growing and has been undergoing enormous changes within its structure, which affect its basic characteristics. Handloom weaving activity plays an active role in the growth process of the state as well as the nation. This sector has been considered important because of the traditional artisan craft skills of the weavers which meet the local needs and demands. Handloom sector has self sustaining mechanism, training for irrespective of gender. The inheritance of skills and capacities is beyond the realm and reach of any modern training and educational institution. However, there is also sufficient flexibility for all types of communities to take up handloom production as a profession. Handloom sector has different strengths in the modern economy. It is simple, and is associated with appropriate technology, the knowledge of which lies with the people. Knowledge dissemination is not locked in any consultancies or training institutions. The very essence of this technology is that it can be assembled by anybody within no time. In a world which is seeking for clean air and water, handlooms are well suited because they are eco-friendly. Energy impacts from handloom technology are almost zero.

The nature of power-loom industry is such that there is great scope for many new comers. It is also true that the industry will survive and prosper because of originality, individuality and workmanship of the artistic weaver. But at the same time it has been rightly observed that with the rapid advancement of textile technology resulting in large scale production of cheap mill cloth and artificial fabrics with captivating designs and texture poses a formidable problem for the future of the power-loom industry. Its general prosperity against powerful competition will not be assured unless the new techniques of production are introduced to suit the changing needs of the time.

The prudent strategy lies in bringing a happy compromise between retaining the cultural heritage of the profession and introduction of modern technology in the weaving

activity. To enhance the scope of weaving activity, measures should also be taken to provide raw materials, finance, marketing facilities and other requirements.

The decade 2006-15 is the decade of manufacturing for India. So there is need for focused attention to the specified sectors of manufacturing which are labour intensive and also enjoy competitive advantage. The textile industry is identified as one such sector. The handloom and power-loom sectors of textile industry have many advantages. To enable these sectors to realize full potential, the bottlenecks which hinder the development must be removed. Both the governments at the national level and state level should recognize the role of handlooms and power-looms in achieving sustainable development. On its own the government would never be able to provide employment to such a large work force. Despite adverse conditions, due to larger support from the consumers and being a livelihood option for millions of weavers, both the handloom and power-loom sectors have been surviving. Government has to ensure a 'level playing field' towards healthy competition among the sub-sector of textile industry.

1. Looms: The process of weaving primarily constitutes interlacement of two sets of threads viz. warp and weft and the equipment which operates this interlacement is called 'loom'.

2. Handloom

Equipments made out of wooden frame to weave cloth by human effort.

3. Power-loom

Equipments made out of iron frame to weave cloth by the use of power/electricity.

4. Pit loom

The loom which stands over a pit and the process of picking is done by throwing the shuttle across slay by hand.

5. Frame loom

The loom used to weave designed varieties with more than two treadles, used in weaving fabric requiring mass production.

6. Semi-automatic looms

The loom operated by human effort by pedaling with legs or by moving the slay by hand.

7. Warping

Lengthwise yarn preparation.

8. Weft preparation

Breadth wise yarn preparation.

9. Weaving

Sending the shuttle which contains the weft thread from one side of the loom to the other through threads of the warp, and in driving the weft threads closely together to form even cloth.

10. Piecing

Joining of the thread ends of the old warp with the thread ends of the new warp.

11. Beam

Wooden / iron reel / drum to wound the yarn required for producing large quantity of cloth.

12. Pirn winding (Weft winding)

Transferring yarn from wooden cone to pirn with the help of spinning wheel, locally known as 'Kandike Suttuvadu'.

13. Reeding or Gaiting up

Drawing the strands of the warp yarn through the eyes of healds (beza) and the dents of the reed.

14. Household

A household is a group of persons who commonly live together and would take their meals from a common kitchen unless exigencies of work prevented any of them from doing so. But not on the road side, pavements or temple mandaps and the like.

15. Household industry

A household industry is one in which an individual unit is run by the head of the household himself and or mainly by the members of the household. Further, the unit does not run as a registered factory.

What once dominated the textile industry has been stunted by the advancement of the technological era. It's true that the only way to create a better future is to create it from the materials of the past. The textile industry is the second largest sector in India in terms of providing employment after agriculture, maintaining the legacy of the country. India has always been at the fore front of textile industry, known for its impeccable craftsmanship in

cotton weaving and dyeing. The centuries old handloom industry alone is responsible for providing employment to as many as 13 million weavers in the country.

However, the good old manually operated weaving industry is dying slowly. What used to be the only commodity-producing sector is now taken over by the more efficient Power-loom sector that use similar techniques for weaving but on purely technological grounds. Most of the 20th century has witnessed the dismantling of the weaving in the mills and a major shift from the conventional weaving to the mechanical weaving called “power-looms”. The phenomenon of a mechanically-powered loom can only be understood in the Indian context. The power-loom industry is now a cornerstone of the Indian economy in terms of foreign exchange earnings and growth of textile industry.

What is Handloom?

A handloom is a type of loom used to weave cloth or patterns on cloth and is operated manually without the aid of electric power. What started as a mechanism to furnish necessities has become a specialized tool for the hand craftsman specializes in furnishing art and luxury fabrics. The growing textile industry has created a vast demand for the handloom weavers which shaped the much of the 19th century cotton industry. No one exactly knows how or when weaving began, but the idea of weaving clearly predates the loom by at least thousands of years. However, the once commodity-generating sector is dying owing to the rise of more efficient modern looms such as power-looms.

What is Power-loom?

A power-loom is a type of mechanically powered loom driven by a steam engine or electric power used to weave cloth. It was not until the 1850's that the power-loom industry really came into the picture, owing to the rising demand of cotton and scarcity of production. Power-looms are a major shift from the conventional handlooms that once dominated the textile industry. As they are mechanically powered, they work at least ten times faster than their handloom counterparts, thereby controlling much of the fabric market. However, a power-loom can only replicate a limited variety of designs and patterns.

Difference between Handloom and Power-loom

Both are tools used to weave patterns of thread into cloth for making woven fabric such as cotton, but this is where the similarities end. This article highlights some key points comparing the two weaving tools.

- 1. Meaning of handloom and power-loom:** The handloom is a manually operated loom used to weave cloth without the aid of electric power. This is a woven fabric that uses

mechanical energy of the weaver and the motion of the handloom is purely manually operated instead of use of electric energy. Loom is actually a device used to weave patterns on fabric and the process is called weaving. Power-looms, on the other hand, are fundamentally different from handlooms and are powered mechanically rather than using human power to weave patterns into cloth.

2. **Operation of handloom and power-loom:** A loom is simply a device used to weave cloth and tapestry and operated wholly or partly by human hands. Manually operated weaving is done on pit looms or frame looms. A pit loom, as the name suggests, is a type of loom set on the floor facing a pit so that yarn can get moisture and two peddles set for the weaver to operate. A frame loom is a self-supported loom that sits above the floor with almost similar mechanism to what the ground looms hold and are mainly used to produce twill, sating fabric. However, both looms can be used to weave malkha cloth.
3. **Efficiency of handloom vs. Power-loom:** A power-loom is mechanized loom which runs by steam or electric power. The looms are driven by a steam engine by belts which lead to more effective and efficient output, plus higher quality of fabric produced compared to handlooms. The handlooms, on the other hand, are used to weave fabric using hand and loom made from wood and the resultant yarn varies according to the materials used and the skill of the weaver, which may result in a less effective fabric. The handloom is the oldest type of loom used for weaving, thus cannot produce complex designs like power-looms.
4. **Meaning of handloom and power-loom:** Both handlooms and power-looms use a small carrier device called shuttle for yarn insertion, except warp threads are raised and lowered by manual shedding in handlooms which requires higher warp shed, which accounts for high-quality woven fabric. Power-looms are modern looms with higher production capacity than handlooms, plus they are able to produce complex designs with less or no human effort. Although, initial investment is high in power-looms, they operate at much higher speeds than their handloom counterparts which results in the production of more variety of designs.

Table 51: Comparison chart between Handloom vs. Power-loom

S. No.	Hand loom	Power loom
1.	Manual operating system	Operated by electric power
2.	Shedding is done by pedal and picking is done by manual	Shedding picking and beating is done automatically
3.	Less production	High production
4.	Slow running speed	High running speed

5.	Initial investment is low	Initial investment is high
6.	Less number of design variety can be produced	More number of design variety can be produced
7.	Check and stripe fabrics are produced	Normally one colour fabric is produced

Summary of Handloom vs. Power-loom

Although both handlooms and power-loom are tools used for weaving patterns or thread into cloth, they are fundamentally different in the way they operate. Handlooms are manually operated looms used for weaving in which picking and beating is done manually by human hands, whereas power-loom are mechanized looms driven by steam engines or electric power in which shedding, picking and beating are done automatically rather than manually. The features alone indicate the main advantages of the more efficient power-loom over the conventional manually operated handlooms. Handloom industry is dying slowly owing to the rise of more efficient and effective power-loom which are capable of producing effective designs at much higher speeds.



Figure 91: Handloom

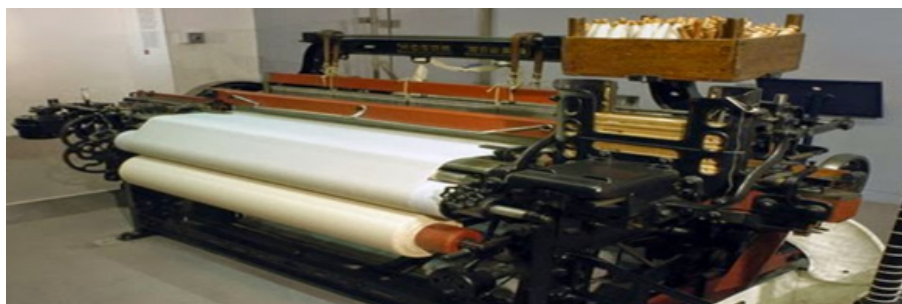


Figure 92: Handloom

Value Addition During Printing

Introduction

The term “value-added” describes the enhancement a company gives its product or service before offering it to customers. It can be considered as an extra special feature added by a company or producer to increase the value of a product or service. Value-added applies to instances when a firm takes a product that may be considered homogeneous with few differences from that of a competitor, if any and provides potential customers with a feature or add-on that gives it a greater perception of value. For instance, a company may add a brand name to a generic product or produce something in a way that no one has thought of before. Adding value to products and services is very important as it provides consumers with an incentive to make purchases, thus increasing a company’s revenue. Offset printing is the most widely used method in the printing industry. A thin film of printing ink is applied onto the printing form via a system of rollers. In one hour, it is possible to print approximately 10,000 sheets using this method. Factors that are crucial to printing quality include the printing inks used with regard to their wettability, gradation, sheen and drying. Offset printing ink consists of the 3 components pigment, binding agent and additives. It is a suspension with complex rheological properties that are influenced by the components used. In the printing process, it is required that smooth and sharply defined tear-off edges are obtained and that scumming (misting) of the ink is avoided. When the ink is transferred to the printing plate and when the latter is moistened, water droplets are formed in the printing ink. When there are such droplets in an ink string that forms in the gap between the printing roller and the rubber blanket, the ink can spray. In practice, relative terms such as stickiness (short, long) and rigidity are often used to describe the properties of a printing ink. In addition, besides rheological variables the tack value (stickiness) is defined as a relative value. A forecast regarding the tendency of printing inks to foam and to spray is desirable for ink development and for their use in the printing machine.

Printing and finishing of textiles are two very important processes which add value to the fabric. A vast majority of fabrics are printed. Unlike dyeing in which the fabric is coloured throughout or in large areas (as in tie and dye) by immersing it in a dyebath, printing is localized application of a dye or pigment to a fabric to generate a pattern or a design. As opposed to normal dyeing which uses a dye solution to apply the dye, in printing a thick dye paste is used. To understand why this is necessary, a very simple experiment may be done. If a drop of colour solution is placed on the surface of a fabric, it is seen to quickly spread into an irregular shape due to capillary effect. To hold the colours in position, thick dye paste is used. This requires the use of thickening agents, which prevent colour migration. The paste holds the dyestuff until it is fixed after printing (say by steaming) and then the unwanted paste ingredients are removed.

Compared to printing, finishing of textiles has a much wider connotation, as one could say that anything which makes a textile attractive is finishing. In this context, bleaching and dyeing (which were covered in the previous lesson) also come within this all-inclusive definition as bleaching makes the fabric white resulting in value addition and dyeing also adds to the value of the fabric by transforming it into an attractively coloured product. Mercerization, which was considered as a preparatory process in the previous lesson, may have a strong claim to be classified as a finishing process as it renders the fabric lustrous and attractive. In this lesson the term 'finishing' would be used in its more restricted sense in which the finish may be applied to get improved handle, easy care, flame resistant, water repellent or wash proof effect, anti-static effect, anti shrink effect, moth and insect resistant, more lustrous fabrics, etc.

Historical Perspective

Hand painting and block printing on textiles are reported to have been practised in India for thousands of years. Hand painting involves directly drawing an image using colour. Alternately, patterns are created on fabrics with the help of the resist technique in which the pattern is drawn on the fabric with clay, starch, gum, or wax, which forms a barrier to dye penetration. Dyeing the fabric then reveals this pattern.

The block printing method was practiced in Sind (now in Pakistan) region in the 8th century from where it came to India. A design was carved on the smooth surface of a wooden block and the raised surface of the block was smeared with the dye paste. The design was then stamped on to the fabric and repetition of this equidistantly all over the fabric gives rise to an attractively printed fabric.

Stencil printing was also practiced in India during the Gupta period (6th to 8th century). The stencil is placed on a fabric and the colour is then brushed or sprayed in the cut out portions, giving beautiful designs.

Machine roller printing came in the latter part of the 18th century and its development could be traced to the block printing process. This eventually transformed the slow and costly block printing process into cheap mass production which revolutionized the cotton print industry.

The stencil printing process led to the development of screen printing which works on the resist principle described earlier. In the early days, fine silk meshes were used as the screen. Towards the end of the 19th century, this process was well developed in Japan. Flat screen and rotary screen machines had by that time made this process very popular for printing.

Methods Used For Printing

1. **Block printing method:** Wooden blocks are made by slicing logs of wood horizontally and the required designs are chiseled on to the hard, smooth block surface. The carved out design on the block is smeared with thick dye paste and then stamped on to the fabric transferring the design as cut in the block. Each separate colour will require a separate block. The process is repeated till the design covers the fabric. Hand block printing is carried out as a cottage or small scale industry in India. It is slow and expensive but is ideal for exclusive designs on limited quantities of fabrics.
2. **Stencil method:** A design shape is cut out of a piece of thin, hard nonabsorbent material and when this is placed on a fabric and the colour brushed or sprayed in the cut out portions, the design is traced on the fabric. An ordinary stencil is shown in Fig. 93.

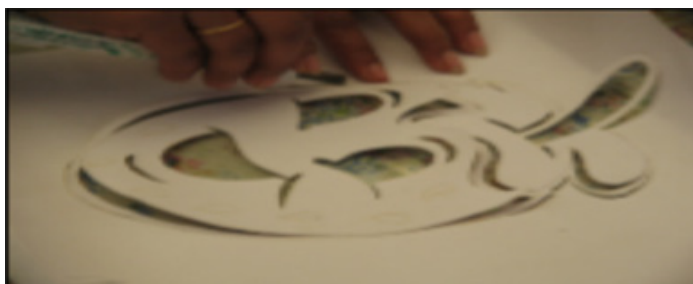


Figure 93: A stencil

3. **Machine roller printing:** Modern roller machine printing is a development of the engraved block method. The principle of the method is shown in Fig. 94. The design is engraved onto a set of copper-surfaced rollers, the number depending on the number of colours in the design. The rollers are situated in sequence round the circumference of a large pressure cylinder whose surface is padded and is protected from staining by dyestuff being pressed through the printed fabric.

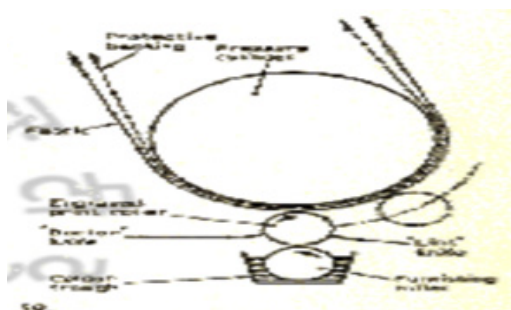


Figure 94: Roller Printing Machine

4. **Screen printing method:** Printing of textile materials using a screen is either done manually or with the help of machines. In the latter category, the automatic flat bed method or the rotary screen printing method are used. In view of its wide use, this method will now be described in greater detail.



Figure 95: Screen frame

5. Screen printing

» Manual screen printing

In manual screen printing the fabric to be printed is laid on a long table. A screen with length slightly greater than the fabric width is fitted in a wooden frame. The design to be printed is transferred to the screen (for each colour, there is a separate screen) and the space in the screen not covered by the design is covered with an impermeable membrane so that the colouring material can only pass through that part of the design which is to be in one colour (Fig. 96).

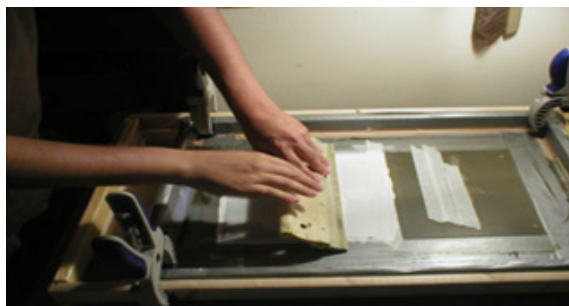


Figure 96: Manual screen printing process

A thick paste containing the colour (dye or pigment) prevents migration of the colour and the paste holds the colour till it is fixed after printing and then the unwanted paste ingredients can be removed. For this appropriate thickening agents are used which increase the viscosity of the paste.

The printing paste is pressed through the screen with the help of a device having a rubber

blade called squeegee (Fig. 97). The screen is moved one repeat and the process repeated. The different colour screens follow and thus the whole length of the fabric is printed.



Figure 97: A Squeegee

6. Semi-automated process

The manual process has been semi-automated by mounting the screen on a carriage and driving the squeegee mechanically across the screen. In both hand and semiautomatic flat screen printing the colours are printed one after another with time for drying between one colour and the next. The dried fabric is removed from the table and stored for a while before fixing by dry heat in the case of pigment printing and steaming or dry heat in case of reactive dye printing.

7. Automated screen printing

» Automatic flat bed screen printing

In order to increase the speed of flat screen printing, it was imperative to devise a method of printing all the colours simultaneously. This entails each colour application position being fixed while the substrate moves. The colour is applied through the screens while the frame is stationary. Flat bed screen printing machines where the fabric remains stationary and the screen moves on a carriage have also been developed for the printing of silk. The entire operation is controlled pneumatically. One such machine is shown in Fig. 98.

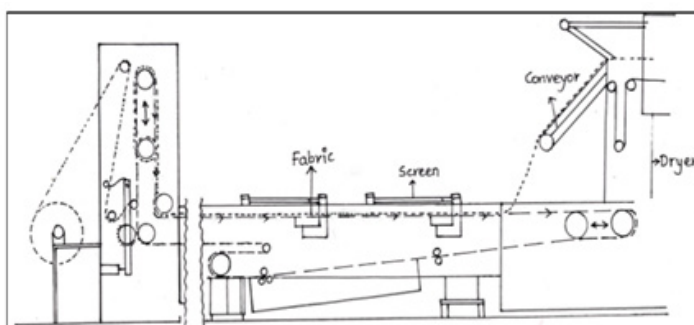


Figure 98: Fully automated flat screen printing machine

» Rotary screen printing

Unlike flat bed machines, in which the printing action is intermittent, continuous movement of the fabric has been achieved in rotary screen printing machines. This is by moving the screens along with the fabric while printing. The screens are cylindrical (Fig. 98 and 99) and the fabric also moves on a cylinder. However, these machines are quite expensive.

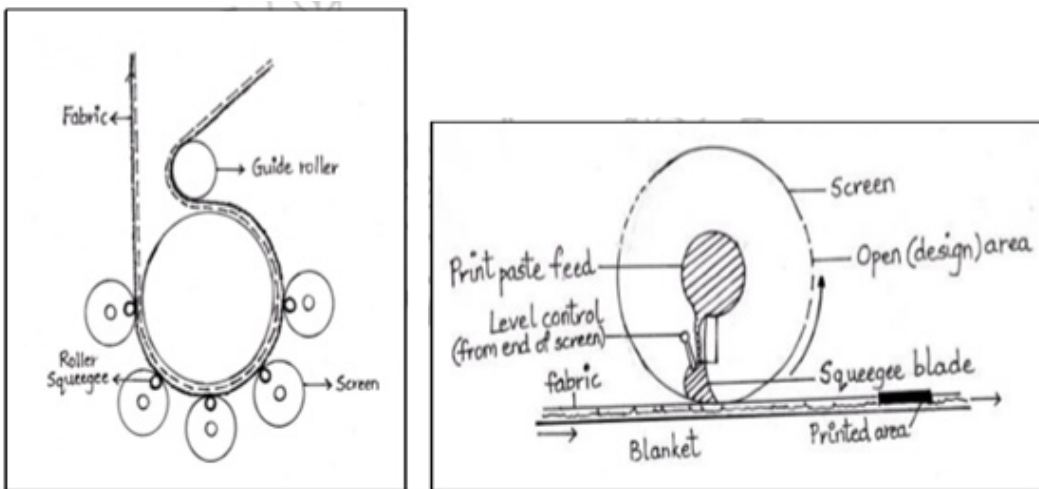


Figure 99: Rotary screen printing set-up and Rotary screen printing section

While that is certainly an option that has worked well for some printing companies, adding value doesn't have to involve large amounts of investment. In fact, many printing companies already have value added solutions in house. It's just that sometimes the true value adding opportunity of these solutions hasn't been seen yet.

So here are six ways in which you can add value to your printing services;

1. **Design:** One excellent (and easy) way to add value is to sell design services as well. Design is much more emotional than print. That means prospects are prepared to pay more for the right level of design.
2. **Web design:** It may seem strange suggesting that printing companies offer competitor channels. However, this allows you to manage a much higher percentage of a client's communications. This can stop a client moving spend away from print to web. It also creates the opportunity to have a much greater relationship with a client and help them with their messaging ideas and strategies, as well as delivering products.
3. **Fulfillment:** Offering just in time printing and fulfillment offers a client the opportunity to reduce wasted material. They are often also able to reduce storage costs and some of their administration overheads. There is potential value here that allows a

conversation that is very different to the cost of print.

4. **Wide format:** Offering wide format services allows an easy upsell to many clients. It also stops them from going to the competition for alternative services. Going to the competition always carries a risk of you losing work or having to reduce prices. Wide format services help create a one-stop shop offering to your clients.
5. **Personalisation:** Research shows that the response rate of marketing has a very definite uplift if pieces are personalised. Printing companies have the opportunity to show their clients how they can add return on investment to their clients' marketing efforts. Basic personalisation does not necessarily mean investing in a lot of expensive software. Once you have shown that this is a proven route to extra sales, you may wish to invest in higher end solutions.
6. **Multi-channel solutions:** Many people are now saying that printing companies need to become marketing services providers. This can involve a big change in culture. You don't have to make such a big leap. Nevertheless, you will definitely add further return on investment for your clients' marketing efforts through multichannel solutions. The addition of personalised URLs and the tracking of the customer journey can be of immense value for your clients. Many print companies have at least some of these solutions in place already. You may have the opportunity to create a value added sales proposition right now. However, not all companies offer these services yet.

5.3 Export and Import Policies: Impact of Silk Import on Domestic Silk Industry, Impact of WTO on Sericulture Industry Introduction

The silk goods exports from India comprise mainly items of Natural silk, Fabrics, Made-ups, Ready-made Garments, Silk Carpets and Silk waste. The category of silk fabrics viz., Dress materials, Sarees and Scarves & Stoles constitute the bulk of silk exports followed by readymade garments with contribution around 60% and 30% respectively to the total silk export earnings of the country. The Indian Silk Goods have high export potential because of its distinctiveness and low production cost. India, being a traditional Sericultural country, holds a unique position in the world, since it has the distinction of cultivating all the four commercially known varieties of Vanya Silks viz., Tasar, Oak Tasar, Muga and Eri, in addition to the mulberry silk. Indian silk exports, which reach more than 190 countries, have increased over the years. The demand for Indian silk is not only in the domestic market but in global markets too. USA, UK, Italy and UAE, German & Spain are the top five importers of Indian silk products. Indian silk are steadily gaining greater demand in the new markets like Latin America and Russia also.

Exports earnings which was 2,294.05 crores during the year 2002-03 has increased to

3338.35 crores during the year 2006-07, showing an increase of around 45.5 %. However, on account of the global financial crisis and sharp depreciation of rupee vis-à-vis the US dollar, there was decline in export of silk goods to the top destinations viz. USA and EU, as a result, slump in silk goods exports from the country was witnessed during first three years of XI Plan i.e., 2007-08, 2008-09 and 2009-10 when compared to 2006-07 (terminal year of X Plan). The export of silk and silk goods during the year 2010-11, was 2863.12 crores indicated a decrease of 1.0 % compared to export of `2,892 crores in the same period of 2009-10.

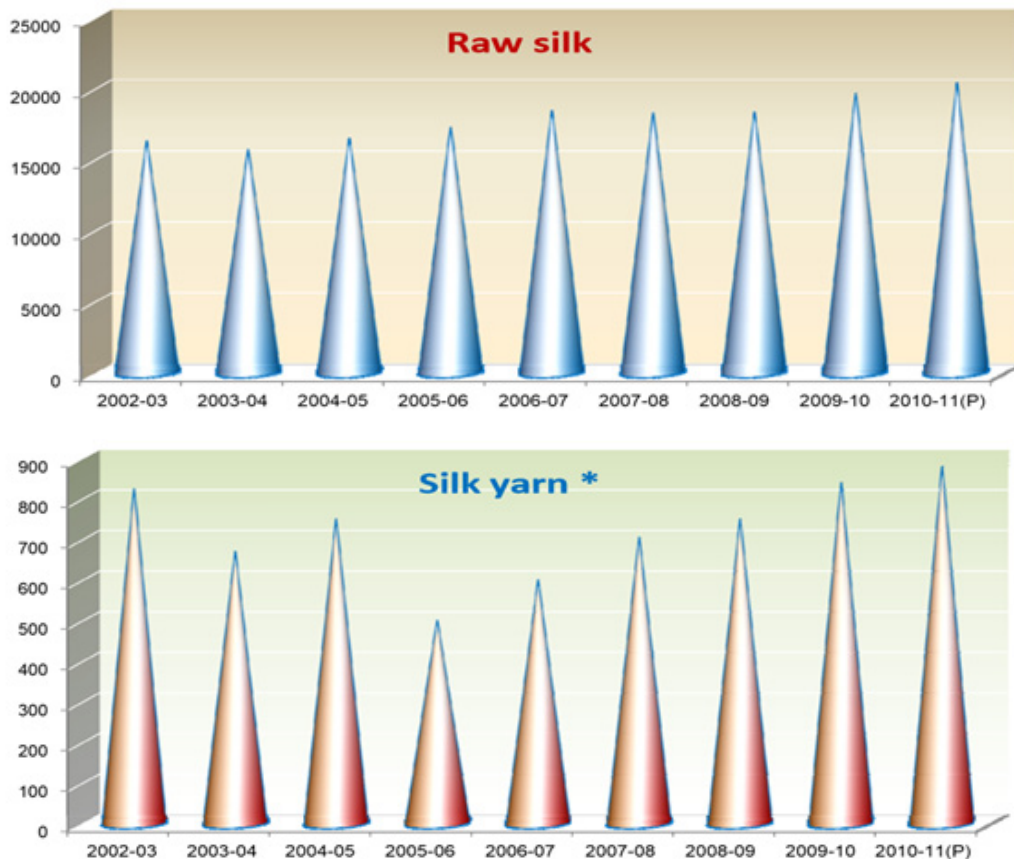


Figure 100: The export of silk and silk yarns during the years 2002-2003 to 2010-11

With sericulture activities spread across 52,360 villages, the Indian silk industry is one of the largest generators of employment and foreign exchange for the country. India enjoys a unique global position in terms of production of all commercially useful varieties of silk. India is the second largest producer of silk. Sericulture provided employment to over 9.1 million people in India during 2018-19.

5.3.2 Key Markets and Export Destinations

1. Exports of silk and silk products from India reached US\$ 291.36 million in 2018-19 and US\$ 116.88 million in 2019-20 (till July 2019).
2. The silk products exported include natural silk yarns, fabrics, made-ups, readymade garments, silk carpets and silk waste.
3. Readymade garments of silk formed the largest share in exports between 2018-19 at US\$ 189 million, followed by fabrics and made ups at US\$ 57.72 million and silk waste at US\$ 18.56 million. Other products made up rest of the export earnings.
4. During April-September 2019, the export of the readymade garments of silk stood at US\$ 68.45 million, followed by silk carpet at US\$ 11.32 million, silk waste at US\$ 7.55 million and fabrics and made ups at US\$ 3.08 million.

Indian Silk Promotion Council

The Indian Silk Promotion Council (ISEPC) has initiated programmes for growth and development of the silk industry. ISEPC organizes trade shows and fairs across the world to promote trade with different countries. The Council also facilitates meetings between exporters and potential customers.

Indian Silk Export Promotion Council

The Indian Silk Export Promotion Council (ISPEC), Mumbai continues to undertake activities relating to promotion of exports of natural silk goods from India and to act as the registering authority for silk exporters. The Council produces and disseminates information to its members about market developments in the world, changes in the trade policies etc. through its monthly magazines known as the “Silk Net”. The silk sample catalogues, containing sample swatches of the full range of silks available in India, brought out by the Council are available to potential buyer, importing textile agents and Indian Mission abroad.

Govt. Policies to Import Silk, Yarns and Woven Fabrics

Procedures to import silk, yarns and woven fabrics

In chapter, a basic knowledge on how to import Silk, Yarns and woven fabrics is explained. This information is to enlighten importers; a general idea to import Silk, Yarns and woven fabrics goods from overseas countries applicable to almost all countries worldwide. Once after reading this post about import procedures and import customs clearance procedures, you will have basic information about the procedures and formalities on how to import various products from foreign countries. Some of the items under this category are prohibited or

restricted in some countries. If you are importing any commodity, you need to obtain accurate information from concerned government departments of importing country, as the details given in this post provides only a common idea about import of Silk, Yarns and woven fabrics.

Different countries have their own requirements to import Silk, Yarns and woven fabrics. However, most of the procedures and formalities are same in all countries after globalization of trade by General Agreement on Tariff and Trade, GATT. More trade liberalization is expected in near future for WTO countries through Trade Facilitation Agreement TFA likely to be introduced within a couple of years.

Specific Requirements to Import Silk, Yarns and Woven Fabrics

1. **Permission to Import only non hazardous dyes** - Import of textile and textile articles is permitted subject to the condition that they do not contain any of the hazardous dyes whose handling, production, carriage or use is prohibited in most of countries.
2. **Anti dumping duty** - Some of the items under Silk, Yarns and woven fabrics attract anti dumping duty, if importing from certain countries as per foreign trade policy of importing country. The importers of Silk, Yarns and woven fabrics may collect accurate information from necessary government agencies before importing.

General requirements to Import

1. Government registration

In most of countries, government registration is required to become an importer in the country who only can act as an importer. Foreign Trade government office of respective country is responsible to issue such authorization to become an importer. For example in India, IEC number (Import Export Code Number) is obtained from the office of Director General of Foreign Trade office to operate as an importer and exporter in India. This process to become an importer is a onetime process, but renewal may be required as per the terms and conditions of such foreign trade office of a country. Nowadays, in most of the countries, the information on such registration for importer – exporter is linked with customs location and reserve bank, as process of imports and exports are online digitalized. So the importers of Silk, Yarns and woven fabrics is also required to contact concerned government agencies of their importing country to verify whether such onetime registration is necessary or not.

2. Formalities to import

The importer and supplier mutually agree terms and conditions about import sale prior to actual shipment of imports. Pricing, quality specifications, terms of payment, terms delivery, and mode of transport and other terms and conditions are agreed and mentioned in purchase order and import shipment of Silk, Yarns and woven fabrics is effected accordingly.

As you know, under any importation of goods, necessary import documentation and customs clearance procedures at importing country have to be completed either importer's customs broker or importer directly as per foreign trade policy of respective importing country. For importing Silk, Yarns and woven fabrics also, import entry documents along with carrier's document (Bill of Lading /Airway bill), commercial invoice, packing list, certificate of origin and other required documents are filed and necessary import procedures are completed to take delivery of imported goods under Silk, Yarns and woven fabrics. Nowadays, necessary information is filed online and produces required documents at the time of inspection, assessment or delivery of import of goods at destination customs location. The international partners of countries share quality measures each other and exempt from multiple inspection on same products both for export and import. However, as per the policy of most of the developed countries import of goods from Least Developed Countries (LDC) need to be certified by authorized agencies before export. So, if any import of Silk, Yarns and woven fabrics takes place, the details of such information can be obtained from necessary government agencies of importing country.

3. Certificate of Origin to Import Silk, Yarns and Woven Fabrics

The source of origin of imported Silk, Yarns and Woven fabrics is required in almost all countries. So a certificate of origin issued by necessary approved authorities at exporting country is required to import Silk, Yarns and Woven fabrics. Certificate of origin helps to determine origin of imported goods to avail exemption on import duties and taxes. Different unilateral, multilateral and bilateral agreement between countries also allows imports and exports with exemption of import duties where in Certificate of Origin is the primary proof on country of origin of importing goods under Silk, Yarns and Woven Fabrics.

In this chapter, the documentation, process and formalities to import Silk, Yarns and Woven Fabrics are explained. As explained above, this information's are generally applicable for all countries. These details on how to import Silk, Yarns and woven fabrics are given to provide a basic idea to bring Silk, Yarns and Woven Fabrics from foreign country. Specific requirements for each importing country need to be followed by importers and exporters of Silk, Yarns and Woven Fabrics.

This list reveals the top 5 silk importers based on their percentage of global import purchases (shown within parenthesis). In 2017, world silk imports totaled US\$ 1.8 Billion.

Italy: US\$331.8 million (18.8% of silk imports)

India: US\$250.9 million (14.2% of silk imports)

Japan: US\$144 million (8.1% of silk imports)

Vietnam: US\$109.4 million (6.2% of silk imports)

Romania: US\$91.2 million (5.2% of silk imports)

25 fastest growing silk importers from 2013 to 2017, overall, the 5 year percentage decline for globally imported silk was -26.7 %.

Table 52: Fastest Growing Silk Import Countries

1. Guinea: Up 56,750% since 2013 (\$1.1 million)
2. Kyrgyzstan: Up 21,767% (\$2.6 million)
3. Egypt: Up 2,362% (\$7.2 million)
4. Cameroon: Up 1,764% 2013 (\$205,000)
5. Zambia: Up 916,1% (\$945,000)
6. Cote d'Ivoire: Up 654, 5% (\$83,000)
7. French Polynesia: Up 600% (\$77,000)
8. Malawi: Up 540% (\$128,000)
9. Turkmenistan: Up 524.3% (\$718,000)
10. Sri Lanka: Up 516.7% (\$21.4 million)
11. Turkmenistan: Up 524.3% (\$718,000)
12. Bosnia/Herzegovina: Up 432.1% (\$1 million)
13. Somalia: Up 367.6% (\$173,000 million)
14. Bermuda: Up 180% (\$112,000 million)
15. Zimbabwe: Up 130.8% (\$90.000)
16. Senegal: Up 124.7% (\$200.000)

African Importers

Africa imported \$86 million worth of silk led by the following countries:

1. Tunisia: \$31.8 million
2. Madagascar: \$31.7 million
3. Egypt: \$7.2 million

4. Morocco: \$5.9 million
5. Namibia: \$1.6 million
6. Lesotho: \$1.3 million
7. South Africa: \$1.3 million
8. Guinea: \$1.1 million
9. Zambia: \$945,000
10. Botswana: \$409,000

Asian Importers

Asia imported \$817.8 million worth of silk led by the following countries:

1. India: \$250.9 million
2. Japan: \$144 million
3. Vietnam: \$109.4 million
4. South Korea: \$63.5 million
5. China: \$50.6 million
6. Hong Kong: \$47.9 million
7. Pakistan: \$40 million
8. Turkey: \$32.9 million
9. Sri Lanka: \$21.4 million
10. Malaysia: \$12.3 million

European Union (EU) Importers

EU imported \$680.3 million worth of silk led by the following EU members:

1. Italy: \$331.8 million
2. Romania: \$91.2 million
3. France: \$78.1 million

4. Germany: \$56 million
5. United Kingdom: \$43.3 million
6. Bulgaria: \$15.7 million
7. Portugal: \$11 million
8. Spain: \$10.5 million
9. Netherlands: \$7.3 million
10. Austria: \$6.5 million

Latin American and Caribbean Importers

Latin America (excluding Mexico) and the Caribbean imported \$16 million worth of silk led by the following countries:

1. Brazil: \$9.5 million
2. Peru: \$2.7 million
3. Colombia: \$1.3 million
4. Argentina: \$1 million
5. Chile: \$368,000
6. Uruguay: \$269,000
7. Panama: \$161,000
8. Bolivia: \$101,000
9. Dominican Republic: \$78,000
10. Venezuela: \$77,000

Middle Eastern Importers

Middle East imported \$46 million worth of silk led by the following countries:

1. United Arab Emirates: \$18.5 million
2. Iran: \$13.5 million

3. Iraq: \$2.6 million
4. Oman: \$2.5 million
5. Saudi Arabia: \$2.3 million
6. Qatar: \$2.2 million
7. Lebanon: \$1.9 million
8. Bahrain: \$911,000
9. Kuwait: \$741,000
10. Israel: \$631,000

North American Importers

North America imported \$94.3 million worth of silk led by the following countries:

1. United States: \$84.6 million
2. Canada: \$7.1 million
3. Mexico: \$2.7 million

Oceanian Importers

Oceania imported \$7.2 million worth of silk led by the following countries:

1. Australia: \$5 million
2. New Zealand: \$1.9 million
3. French Polynesia: \$77,000
4. Samoa: \$52,000
5. Fiji: \$47,000
6. New Caledonia: \$38,000
7. Papua New Guinea: \$24,000
8. Solomon Islands: \$8,000
9. Kiribati: \$1,000

Impact of Silk Import on domestic Silk Industry

Sribhas Chandra Supakar, a Varanasi-based textile designer, hopes India will soon stop importing raw silk. “Whenever there is a spurt in prices of imported raw silk, it impacts prices of domestic silk as well,” he says. “If we can eliminate imports, this volatility will end.”

That wish may come true within a few years. The silk industry in India, with a 15 per cent share of global output, is seeing a ‘swadeshi’ movement. Over the past five years, domestic production of raw silk has risen about 30 per cent to 23,679 metric tonne in 2012/13 from 18,320 tonne in 2007/08. Imports of raw silk fell 38 per cent to 4,951 tonne from 7,922 tonne during the same period. The trend continues in the current fiscal year as well, with imports in the first six months (April–September 2013) touching just 1,175 tonne. India imports mostly from China, which has a share of nearly 82 per cent in global output. “We aim to eliminate silk imports and make India self-sufficient by 2020,” says K.K. Shetty, Joint Secretary at the Central Silk Board, which functions under the Ministry of Textiles. The ministry has set a target of increasing production to 32,000 tonne by 2016/17 by growing the area under sericulture and improving productivity. Textiles Minister K. Sambasiva Rao has since raised the bar higher, saying in December that output should go up to 46,000 tonne by that time.

Shetty says domestic silk is also priced competitively. Imported silk yarn sells for Rs. 4,500 per kg while domestic yarn is available for Rs 3,500 to Rs 3,800 per kg. According to Shetty, handlooms account for about 85 per cent of silk consumption in India while power-looms use the remaining. The country, the biggest consumer of silk globally, has now started producing the bivoltine grade of the fabric that can be used by power-looms. “We have developed silkworm seeds that can produce silk suitable for power-looms,” he says.



Figure 101: A new shine: A silk handloom weaver in Varanasi

The impact of silk imports on domestic silk industry and sericulture are analyzed based on available data up to the year 2005. While the paper doesn't offer any solutions for the problems, a few issues are thrown up which call for immediate research attention. The available (very few) studies on the economic issues of Indian silk industry are reviewed. The analysis has been restricted up to the year 2005 considering the fact that no much change has taken place in the industry since then. Silk has a miniscule percentage of the global textile fibre

market- less than 0.2%. But this figure can be a gross under-estimation, since the actual trading value of silk and silk products is much more. The unit price for raw silk is roughly twenty times that of raw cotton. The annual turnover of the China National Silk Import and Export Corporation alone is US\$ 2–2.5 billion (ITC Silk review, 2001). Sericulture has important socio-cultural implications. Studies have established large scale employment generation potential and high income generation potential of sericulture (Hanumappa, 1986). Jayaram *et al.* (1998) showed that every acre of sericulture practiced under irrigated conditions had a potential to employ 247 men and 193 women round the year. They have also shown that the small scale mulberry farms provided ample scope for employment of owned family labour and suggested its potential to solve the problem of seasonal unemployment. Lakshmanan *et al.* (1999) found that female labour is quite dominant in all sericultural activities, to an extent of nearly 50%. Saraswathi and Sumangala (2001) observed that in the indoor activity of silkworm rearing women participation was as high as 94.67 % and that except for the peak period the entire sericultural activity is conducted using family labour. Most of the activities in silk production are in the informal sector and menial in nature. Thus about 90% of the employment goes either to the landless or to the marginal farming families that hire out these labour, or to the sericulture families (Sinha, 1989). While considering the price spread in the whole industry, it can be seen that 48% of it goes to farming sector, as illustrated below. Sericulture and silk production are labour-intensive at the village level, employing both men and women at all stages of production. In China, it occupies some 20 million farmers, as well as 5 lakh people in the silk processing industry (ITC silk review 2001). In India, sericulture is a cottage industry in 59,000 villages, providing full and part-time employment to some six million people from the farm sector, and silk processing industry (ITC silk review 2001).

Inability to Exploit Export Potential

Table 53 gives India's export, import and demand supply gap. The annual production of raw silk in India was 17305 tons, of which mulberry raw silk alone accounts for 15445 tons in 2005. The demand for raw silk was much higher than the production at 10180 tons. Hence, India imported 10538 tons of raw silk in 2005. The imports have steadily increased from 6015 tons in 2000 to 10538 tons in 2005 representing a compound annual growth rate of 9.8%, against a mere 0.25% compound growth rate in production. Over the five year period the demand supply gap has increased by 73%. The imports as a percentage of production have increased from 39% to 68%. This analysis indicate that India has neither been able to meet the increasing demand for silk in the domestic market by increasing domestic silk production, nor to exploit the huge export potential; instead resorted to raw silk imports to fill the domestic demand supply gap.

Table 53: India's raw silk production, export, import and demand supply gap

Year	Silk production in tons	Export in tons	Import in tons	Demand supply gap (in tons)
2000	15214	163	6015	5852
2001	15857	513	7896	7383
2002	17351	263	10506	10243
2003	16369	384	11365	10981
2004	14620	466	10646	10180
2005	15445 (0.25%)	582 (23.63%)	10538 (9.8%)	9956 (9.26%)

Table 54 gives India's export earnings from silk (all commodities) over the period 2000 to 2005. It is seen that though the silk exports showed a compound growth rate of 7.95% over the years, its percentage share in total textile exports from the country has been stagnant over the years. From the above analysis it is clear that even after being the second largest producer of silk, India contributes only 16% of global silk production and it is the largest importer of raw silk. India has been unable to meet the increasing demand for raw silk by the domestic industry through increasing domestic supply. This is because of two reasons namely low productivity and low quality.

Table 54: India's export earnings from silk (all commodities) in million US dollars

Year	Silk Exports	Total textile exports	% share of silk
2000	405	6096	7
2001	530	5410.41	9
2002	495	6098.23	8
2003	474	7108.2	7
2004	605	7172.99	8
2005	641 (7.95%)	9147.78 (7%)	7

Table 55 gives the value of silk and other textiles imported by India over the years. The percentage share of silk in the total textiles import has increased over the 6 years by 5.7%, whereas the net foreign exchange earning from export and imports has remained stagnant.

Table 55: India's silk imports (all silk commodities) in million US dollars

Year	Silk Imports	Total textile imports	% share of silk	Net foreign exchange earning
2000	126.42	1181.42	10.7	279
2001	170.9	1521.22	11.23	359
2002	195.48	1614.29	12.11	300
2003	252.29	1965.37	12.84	222
2004	304.84	2116.77	14.4	300
2005	399.64 (21.15%)	2670.75 (14.56%)	14.96 (5.74%)	241

From the above analysis it is clear that even after being the second largest producer of silk, India contributes only 16% of global silk production and it is the largest importer of raw silk. India has been unable to meet the increasing demand for raw silk by the domestic industry through increasing domestic supply. This is because of two reasons namely low productivity and low quality.

Impact of Cheap Imports on Domestic Industry

Apart from India's inability to exploit the export potentials and dependency on imported raw material, another grave issue is pertaining to cheap imports of raw materials ruining the domestic sericulture industry. It is reported that Chinese raw silk and silk fabrics are reportedly being imported into the country at very low prices (Tikku, 1999).

The data furnished in Table 55 reveal that the raw silk imports to India increased from 7896 tons in 2001, to 10506 tons in 2002, which is a 33% increase in one year. During the subsequent year the domestic silk production fell by 5.6% (from 17351 tons of 2002 to 16369 tons of 2003). The domestic silk production further fell by 10% (from 16369 tons of 2003 to 14620 tons of 2004).

Table 56 compares the annual growth rate in raw silk imports for five years from 2000 against the performance of Indian sericulture industry and reeling sector to generate an idea about the comparative dynamics.

It is seen that the growth rate of silk imports were very high from 1999 to 2003 except for 2000-01. The growth rate in the value of imported silk (in Indian Rupee terms) has been lower than that of quantity of imports. The prices of domestic raw silk and cocoon are observed to be worst affected during the years 2001-02 and 2002-03, the periods in which imports grew very high and prices of imported silk kept falling. Thomas *et al.* (2005a) showed that the cocoon price get influenced by the yarn prices with a lag of six to ten days. From

the Table 56, it is clear that during 2001-02 and 2002-03 when domestic raw silk prices fell by 4.9% and 24.1 % respectively, the cocoon price also fell by 4.8% and 10.8%. This has impacted on cocoon production, lowering it by 8.2% and 8.4% during 2002-03 and 2003-04 respectively. The data shows that the effect of imports influenced the mulberry plantation also. During 2002-03 in Karnataka alone 23% of the existing mulberry plantations were uprooted and in the subsequent year another 10% uprooting occurred. 6780 charka reeling units have closed down over the six years where as the number of cottage basin reeling units have increased by 846 only. The number of multi-end reeling units has also fallen by 59. This means considerable labour displacement from the charka sector during the six years which is not likely due to up gradation of the charka units into cottage basins.

Table 56: Growth rate in raw silk imports against performance of Indian sericulture industry

Year	Raw silk import % growth rate		Cocoon price / kg (Rs)	Rawsilk price / kg (Rs)	Cocoon prodn. (in tons)	Mulberry hectare in Karnataka	Number of reeling units		
	Quantity	Value					Charkha	Cottage basin	Multi- end
1999-00	77.7	59.1	108.3	1015	124531	120119	34794	25785	260
2000-01	-6.1	15.1	125.9 (16.25)	1116 (9.9)	124663 (0.1)	112557 (-6.30)	35490	25988	258
2001-02	44.5	31.5	119.9 (-4.8)	1061 (-4.9)	139616 (11.9)	116158 (3.20)	32321	28051	299
2002-03	32.9	3.6	107 (-10.8)	805 (-4.8)	128181 (-8.2)	88903 (-23.46)	29733	26939	220
2003-04	2.3	-2.9	126 (17.6)	984 (22.2)	117471 (-8.4)	79778 (-10.26)	28014	26631	201
2004-05	-14.1	-3.4	114 (-9.52)	915 (-7.0)	120027 (2.2)	77998 (-2.23)	28014	26631	201

The fall in: prices, quantity of cocoon production and mulberry area and labour displacement from the reeling sector cannot be completely attributed to the raw silk import. Many other socio economic factors could be at play. However it is seen that subsequent to a protectionist intervention of the government during 2003, the quantity of imports fell by 2.3%, domestic raw silk prices increased from Rs. 805.00 to Rs. 984.00 per kg (22.2% growth) and cocoon prices increased by 17.8%. During the subsequent year the quantity of cocoon production showed slight improvement (2.2% growth) and the mulberry uprooting rate came down from 10.26% to 2.23%. This indicates that the silk imports have had a deleterious effect on the domestic sericulture.

It is generally held that the imported raw silk is consumed by the power-looms since

power looms require qualitatively superior and strong yarn for the warp and the relatively poor quality local yarn is fit for the weft only (Thomas *et al.*, 2005b and Vasumathi, 2000).

Table 57 gives the growth rate of raw silk imports over 6 years from 1999-00 against number of handlooms and power looms in the country. It is seen that the number of power looms have stagnated at 29340 over the years and the number of handlooms have increased by 30299 during 2001-02. The raw silk imports have been in the increase. Thomas *et al.* (2005b) found that only 50-53% of the yarn requirement of the power loom sector is met from Chinese imports. Thus it may be inferred that a considerable portion of the imported yarn is being absorbed by the handloom sector also, which is traditionally known as the sole consumer of charka silk (Vasumathi, 2000).

Table 57: Silk handloom and power looms in India

Year	Raw silk import % growth rate		Hand looms (number)	Power looms (number)
	Quantity	Value		
1999-00	77.7	59.1	227701	29340
2000-01	-6.1	15.1	227701	29340
2001-02	44.5	31.5	258000	29340
2002-03	32.9	3.6	258000	29340
2003-04	2.3	-2.9	258000	29340
2004-05	-14.1	-3.4	258000	29340

A study conducted by Thomas *et al.* (2005 b) revealed the pattern of raw silk usage as given in Table 58.

Table 58 Pattern of raw silk usage by power looms in Karnataka (Source: Thomas *et al.*, (2005 b))

S. No.	Yarn type	% Use
1.	Chinese yarn for warp	50.52
2.	Local BV hybrid yarn for weft	4.31
3.	CB yarn for weft	45.16

Thomas *et al.* (2005b) also have shown that the imported Chinese silk is superior to the locally available silk with respect to denier, cleanness, cohesion, gumming losses and uniformity.

Table 59: Comparison of imported silk with local raw silks based on these attributes

S. No.	Parameters	Chinese A grade silk	Local bivoltine A grade silk	Local cross breed A grade silk
1.	Denier	19.95	20.25	21.4
2.	Cleanness	9.1	8.5	7.4
3.	Cohesion	8.5	8	7
4.	Winding breaks	8.5	7.75	6.53
5.	Degumming losses	21.6	24.25	24.9
6.	Uniformity	9.28	8.75	7.7

Naik. G & Babu (1993) have estimated that the total high quality silk production in India could meet at the most 60 per cent of the estimated demand and have cautioned about the negative implications of the Chinese raw silk on the development of Indian silk industry. They also noted that diversion of imported silk into domestic sector benefit only the consumer. By avoiding this diversion, the demand for domestically produced high quality silk would have increased the good health of the industry. Some of their recommendations for amelioration of the current situation include - improvement in research and extension facility, adequate supply of inputs and proper marketing facilities and modifications in the production system.

Impact of WTO on Sericulture Industry

Under World Trade Organization (WTO) regime and General Agreement for Trade and Tariff (GATT) with liberalized trade policies, India not only has to increase its silk production but also improve silk quality standards, if it really wants to be competitive in the world silk market. Apart from this the fashions are changing with the changing times in the domestic market also which demands for quality silk. The challenge before us is to direct our production strategies to suit the domestic and global silk market. Unless bi-voltine cocoons are made available in sufficient quantities throughout the year and more importantly at prices comparable internationally, Indian silk industry cannot reach the desired levels of competence in production of silk. The demand for Cocoons is in far excess of the supply and this is also leading to very high price levels for the cocoons in the country. Therefore, the challenge before India is to reorient the production strategies to suit the requirements of both national and international markets, by developing better quality silk with reasonable lower cost.

The world silk production has crossed the 10 million tonnes in the mid 90's with china forging a giant leap forward overtaking Japan in the early 80's. The Indian textile industry has a strong socio economic significance in India's national economy. It contributes around 5%

of GDP and accounts for over a third of country's total export. It is also the largest foreign exchange earner of the country. The versatility of Indian silk is unmatched the array of silk fabric produced by our traditional craftsman is found increasingly acceptable to the changing fashion world of Europe and the USA. Fashion means fantasy, innovation and versatility. All these are the hall mark of Indian silk which can offer a wide range of woven design to the affluent European markets where it is a fashion to change fashion at supersonic speed. The biggest strength of Indian silk undoubtedly is at capacity to supply a wide range of hand woven design of fabric in short length and in short notice. Although the power-loom fabrics are fast replacing the share of hand-woven silk fabric in export, our traditional have made silks from Banaras, Mubarakpur, Kanchipuram, Dharmavaram etc. will continue to find a prominent place in silk export basket. Our hand-woven, hand printed and hand painted dress materials and scarves continue to sustain its export demand even today.

Dandin and Gupta's (2002) study revealed that the sericulture has now become a lucrative and remunerative enterprise in India. However due to present changing situation arising out of WTO introduction and decline trend in the sericultural activities in Japan, Korea, USSR etc. a vacuum has been created in the global demand and supply of silk. India has to take a serious concern by switching over to bivoltine culture in addition to cross-breed and trading multi-voltine rearing in mulberry sericulture and by utilizing national genetic resources in mulberry (Tasar, Eri and Muga) sector. They have given a realistic plan for development of an efficient strategy of integrated technology for sericulture development. Therefore under WTO regime and GATT agreement with liberalized trade policies, India has to plan a sustainable strategy not only to increase its silk production but also to improve silk quality standard, if it really wants to be competitive in world silk market.

Since the emergence of globalization of trade, many things came in to focus. The cost of transport has been reduced, the time taken for goods to transport from one place to another has been shortened and bilateral and multilateral trade agreements to remove restriction on free trade have been signed. Many regional free trade agreements have been signed and today there is no nation in the World which is not a member of one or other free trade agreements. Apart from regional groupings of nations such as North American free trade Agreement (NAFTA) and European Economic Community (EEC), Global trade negotiation grounds, originally under the auspices of GATT led to a series of agreement to remove barriers against free trade. The Uruguay Round (1984 to 1995) created World Trade organization (WTO) to settle trade disputes and set up a uniform platform of trading. Even the feuding of South Asian countries are trying to convert SAARC in to free trade.

Given the global and domestic demand for India distinct and traditional silk products, overseas investments including that in silk plantations and measures to promote captive silk production are gaining momentum. The union textile ministry is reportedly exploring the opportunities in Africa to secure supply of silk. Several African countries are seeking overseas

direct investment by Indian companies to promote silk production and export. However, a strong case exists for encouraging domestic production of silk and sustaining traditional silk crafts and skills. On a whole, Indian's silk based industry has to move from or cottage based production to large scale manufacturing as in china. So as to compete with China, India manufacturer should develop their production technology since Chinese authorities have actively promoting silk development and are encouraging the production of Indian silk textile, including traditional Indian silk textiles.

Summary and Conclusion

In spite of its small volume in global textile production, silk has importance in developing economies primarily because of its favorable socio economic consequences. The development of sericulture had been the states priority in every country. The case of Indian sericulture is no exception to this. A number of regulations were made in favor of the farm sector. Many ambitious projects were launched and a large number of technologies made available. In spite of all this, poor productivity, poor quality, high cost of production and labour intensity continue to be the hall marks of Indian silk industry. In order to cater to the needs of sophisticated power-looms and in response to the relaxation in exim policies, large quantities of high quality silk has been imported at prices lower to local silk. This has disrupted the domestic silk reeling industry and sericulture farm sector, leading to considerable labour displacement. Protectionist government interventions have temporarily eased the problem. But how long tariff protections could help the domestic industry is a question. Data shows that imported silk is finding place even on the traditional handlooms, clearly demonstrating its comparative advantage. The recent data shows that the price of imported silk is in the increase while the government has announced a slash in customs duty of raw silk imports from 30% to 5%. While the farmers and reelers staged an agitation the weaving sector welcome the gesture. Thus the industry is divided in its opinion on cheap imports, indicating the necessity for the government to take appropriate policy decisions.

5.4 Cocoon in Crafts

Craft is an activity such as weaving, craving and pottery that involves making things skillful by hand. Cocoon can be processed into various crafts. Cocoon crafted was first started by Mr. Chidambaram and Mrs. Chidambaram on 6th of Dec. 1935 at Tamil Nadu.

Generally, unreelable cocoons are used for making crafts. Cocoon crafts include earring, bouquet, bracelets and cocoon flower etc. Thus, we can say that craft of cocoon raise the level of sericulture farmer by increasing their economy.

Silk in Craft

Silk is being light and strong used extensively for making various crafts. Different articles like garlands, flower vase, wreath, pen stand, dolls, jewellery, wall hangings, wall plates, bouquet, and greeting cards are being prepared using the waste silk cocoons.

In Japan some laboratories have produced silk paper in different colours for making crafts like flowers and lamp stands.

Input Regimes for Cocoon Crafting

(a) Basic raw material

The basic raw material, (cut/pierced cocoons) is procured from any government or private grainage (SSPC). Rejected (dead/double) cocoons can also be used as substitute raw material to earn the return. These cocoons are cut open from one end and the cap portion thus obtained along with cocoon body can also be utilized for preparation of some handicraft products.



Figure 102: Basic Raw materials (Cocoons) for crafts

(b) Other miscellaneous material

The items required, based on the type of cocoon handicraft to be designed are scissors, zig-zag scissors, blade, cotton thread, cardboard, drawing sheets, needles, fabric glue, craft paper, glaze paper, velvet paper, adhesive tape, colour tape, stapler, plastic ornamental material, soft binding wire, beads, chemical dyes and dyeing vessel, besides, heater required for cocoon dyeing. Instead of heaters, fire wood used for domestic purposes can also be utilized for cocoon dyeing. Fabric paint and water colour can also be used during cocoon craft fabrication.

Materials and Methods for Development of Cocoon Crafts

1. **Small Scissor:** It is used to give the desired shape to the cocoon and to cut the designer paper sheets etc.

2. **Zig Zag Scissor:** During the preparation of garlands, this type of scissor is used to cut the cocoons so as to make its edges serrated.
3. **Paper cutter and Blade:** These are used to cut the cocoons/paper sheets to the desired size and shape for innovating a design.
4. **Fancy Plastic/Wire:** It is used in the preparation of stalk of cocoon flowers. Soft wire can be also used as a substitute material for it.
5. **Satin Ribbon:** It is used to enhance the aesthetic look of the flower bouquet, by tying it around the bouquet.
6. **PVC Sheet:** It is required in the preparation of single and “bunch flower bouquets”.
7. **Cotton thread & Needle:** It is used in stitching of garlands.
8. **Velvet (handmade paper) Sheet:** It is used in preparation of “flat flower bouquets”.
9. **Gum:** It is used as an adhesive to fix the cocoon material during designing of various craft items.
10. **Paint Brush:** It is used for colouring of the cocoons to be utilized in craft work.
11. **Sketch Pens:** They are used as colouring material in the designing of greeting cards.
12. **Dyes:** Chemical dyes are used for cocoon dyeing.
13. **Adhesive Tape:** It is used as an adhesive material in fixing and attaching the cocoon flower bouquets.
14. **Drawing Sheet:** It is used for preparation of flat flower bouquets and greeting cards. It can be substituted by craft sheets.
15. **Fabric Paint:** It is used in painting of the cocoons for fancy hand product designing.
16. **Beads:** These are used in preparation and decoration of small cocoon cap and other types of cocoon garlands.
17. **Stapler:** It is required to pin the edges of the bouquets, cards etc.
18. **Glaze Paper:** Glaze paper sheets are required for wrapping the flower bouquets.



Figure 103: Materials for the Development of Cocoon Crafts

The cocoon by-products (raw material), after procurement, are to be sorted out for uniform size and shape. The stained and dirty cocoons are rejected from the sorted lot. Later on the sorted cocoons are to be deflossed. These deflossed cocoons are dyed for desired colour and then given proper shape as per the product design by using blade, scissors etc. The cap portion of the cut cocoon can be used in the preparation of small beaded garlands, greetings cards and as assembled parts in designing of various fancy items.



Figure 104: Cocoons Garlands

Method of Cocoon dyeing

Different colours give charm and glamour to the objects, adding to its visual appeal. Colouring/ dyeing is an basic requisite of cocoon handicraft preparation and gives colour look to the cocoons. Cocoons should be preferably dyed with natural colour, which is going to add value and originality to the creativity of the craftsman. Use the chemical dyes which are used for colouring the silk yarn/fabric. Use only soft water in dyeing the cocoons as hard water consumes more quantity of dye and it may also result in uneven dyeing.



Figure 105: Dye cocoons

Bring the water to boil and take the desired dye powder with needed quantity. About 100 gm of dye is required for 1 kg cocoon dying. Mix it initially with 100 ml of hot water. Stir continuously to avoid formation of clumps and then filter the dye solution. Next add this dye solution to the hot water and stir it continuously for uniform mixing of colour. Then dip the clean, deflossed and double, rejected cocoons in this solution. Stir it again continuously till the colour absorption of dipped cocoons is uniform: Cocoons should be dipped upto the temperature range of 50°C only, otherwise the higher temperature will effects its sericin content giving deformed look to these cocoons. Then the dyed cocoon should be removed from the solution and allowed to dry in a single layer under shade only, to avoid its decoloration. Now the dyed cocoon material is ready to be crafted into desired products.

Designing of cocoon craft products

1. Cocoon flower

Cut the cocoon dyed with natural colour in the shape of petals making 3 to 4 petals per cocoon. Take 3-4 such cut cocoons; arrange them in a flower shape. Then fix the petals with glue. Dry these flower cocoons and pierce a sharp needle in its centre to insert a soft fancy wire and knot it at the top as well as bottom of the flower which will act its stalk. Cut other green dyed cocoons in the shape of leaves. Then arrange these leaves in a way around the flowers to give it a natural leafy look. An artificial plastic leaf can also be used as a substitute of the purpose.



Figure 106: Cocoon Flower

2. Single flower bouquet

It is prepared by arranging/fixing a single or 2-3 flowers along with leaf to the branch shaped green plastic wire. Then it is wrapped in a conical transparent PVC sheet and in turn covered by a glaze paper with cello tape. It looks like a fresh flower bouquet.



Figure 107: Single flower bouquet

3. Flower “Bunch” bouquet

Take about 25-50 bunch of cocoon flowers of different colours and arrange them in a flower bouquet shape. Number of flower cocoons depends upon the size and design of the bouquet to be prepared. Then wrap it in a transparent PVC sheet and in turn with a glittering craft paper to give it bouquet look.



Figure 108: Flower “Bunch” bouquet

4. Garland designing

Following different types of garlands can be designed from cut cocoons.

(i) Single flower garland

This type of cocoon garland is prepared by using the cut end of the cocoons. Give shallow cut to the cocoons from the cut/pierced end side of it with a small scissor to give it a flower petal shape. Then insert a colour cocoon or other flower into this cocoon flower. After this

add one or two gold coloured beads through the basal end of this cocoon flower, followed by a flower and beads again alternately with the help of a needle/thread forming a shape of garland. Number of cocoons in preparing the garland is subject to its required length. This is a simple type of garland with an elegant look and can be designed with three line orientation like a “Har” with central cocoon pendulum design.



Figure 109: Single flower garland

(ii) Flower “Bunch” garland

Cut the open end of the “cut cocoon” by using a zig zag scissor. Stitch or fix 5-6 such cocoons joining their ends firmly. Such more stitched circle of cocoons (bunches) can be stitched further by thick thread to give it a shape of garland. Multicoloured cocoons can be used to grace the look of the garland. About 500 cocoons are required for preparation of the garland with heavy bouncy look. Cocoon flower garlands look more graceful and last for years to come. About 6 heavy garlands can be prepared from 1 kg cut/pierced cocoon.



Figure 110: Flower “Bunch” garland

(iii) Cocoon cap garland

The caps removed during inner cleaning of the cocoons, can be fixed together just like two halves of a walnut with the glue. These differently coloured caps are stitched/intermixed with golden beads in a line to form a garland with beaded look. White and colour caps beaded together add to its visual appeal. This type of garland is very light, delicate with decent look and easy to carry as a surprise gift.



Figure 111: Cocoons cap garland

5. Greeting card preparation

In greeting card preparation, both white and colour cocoons are used. These cocoons are cut into small pieces of various designs so that these are shaped as flowers, trees, and other scenic objects including small huts, animals, birds etc. Then fix these shapes on a piece of a craft/ drawing paper and use water colour/sketch pens wherever necessary to design and paint the card. These cards look awe-some with full emotional expression as being hand crafted from the natural material. An occasion specific message carved on this card with “small cocoons pieces” shall mark the moment with nostalgic memories.



Figure 112: Cocoons greeting card

6. Fancy items of gift/interior decoration

Small gift/decoration items like colourful birds, images of deity Ganesha etc., miniature mulberry or other trees, historic monuments like Taj Mahal and mythological Snowman, or any other items of aesthetic value which will exhibit the creative skill of craftsmanship, can be prepared and designed by utilizing cocoon by-products and waste deformed/ rejected cocoons. The cocoons are cut into small pieces of various designs, and these pieces are assembled together to form a particular shapes and fixed on craft, velvet or drawing paper. After giving it a finishing artistic touch, fancy product thus prepared can be glass framed and presented as gift or sold in the market. These items exhibit exquisite look and attract the attention of dignitaries and customers.

Table 60: Silk Yarn Total (2002-2003 - 2015-2016)

Year	Mulberry Silk	Vanya (Non-Mulberry) Silk-Tasar	Vanya (Non-Mulberry) Silk-Eri	Vanya (Non-Mulberry) Silk-Muga	Total (Mulberry+ Vanya)	Silk Yarn- Spun Silk Yarn	Silk Yarn- Noil Yarn	Silk Yarn- Total
2002-03	14617	284	1316	102	16319	550	275	825
2003-04	13970	315	1352	105	15742	446	224	670
2004-05	14620	322	1448	110	16500	500	250	750
2005-06	15445	308	1442	110	17305	350	150	500
2006-07	16525	350	1485	115	18475	400	200	600
2007-08	16245	428	1530	117	18320	470	235	705
2008-09	15610	603	2038	119	18370	500	250	750
2009-10	16322	803	2460	105	19690	560	280	840
2010-11	16360	1166	2760	124	20410	585	295	880
2011-12	18272	1590	3072	126	23060	645	330	975
2012-13	18715	1729	3116	119	23679	770	385	1155
2013-14	19476	2619	4237	148	26480	850	430	1280
2014-15	21390	2434	4726	158	28708	NA	NA	NA
2015-16	20478	2819	5060	166	28523	NA	NA	NA

Table 61: Silk Yarn Total (2002-2003 - 2013-2014)

Items	2007-08 Quantity	2007-08 Value	2008-09 Quantity	2008-09 Value	2009-10 Quantity	2009-10 Value	2010-11 - Quantity	2010-11 - Value	2011-12 - Quantity	2011-12 - Value	2012-13 - Quantity	2012-13 - Value	2013-14 (P) - Quantity	2013-14 (P) - Value
A	Silk Goods	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
I.	Mulberry	NA	2533.79	NA	2907.92	NA	NA	2568.69	NA	NA	NA	NA	NA	NA
	Dress Material	2344716	1259.29	2081203	1354.39	2134191	2029954	1449.47	953748	840.29	10446367	725.41	6279800	436.08
	Ready Made Garments	3479203	746.55	3425968	986.57	2309419	1596151	683.32	1920557	765.83	23284282	787.15	3100000	1453.85
	Carpets (in sq.mt.)	69021	72.11	72838	58.67	43910	29990	21.1	32042	20.08	73973	21.14	46000	15.65
	Sarees	213648	77.05	102505	127.35	126931	158879	100.92	58519	44.95	712129	44.9	428000	26.26
	Scarves/Stoles	1023959	220.15	1023132	229.12	736058	432169	209.75	341348	250.28	8305422	352.98	5010300	212.94
	Ties	4307	2.31	12403	6.95	63943	15121	9.72	6461	5.34	14051	1.05	8400	0.63
	Others *	807672	156.33	227395	144.87	1111341	589816	94.41	370054	68.04	3708258	65.88	2229000	39.6
II.	Non- Mulberry (Vanya)	552051	118.92	931639	208.67	570823	396718	192.54	363592	266.6	4772963	202.852	2869000	121.94
III.	Mixed Blended	82009	17.63	94665	21.29	154162	96388	27.01	89889	22.47	703069	17.24	422400	10.36
	Total for A (I+II+III)	NA	2670.34	NA	3137.88	NA	NA	2788.24	NA	2283.88	52020514	2218.602	NA	2317.31
B.	Raw Silk & Silk Yarn#	944698	45.38	234960	35.08	473658	264623	39.38	220449	19.68	150671	21.96	53500	8.56
C.	Silk Waste	755155	12.15	291155	5.23	1504169	1651851	36.14	1877565	49.77	1610250	62.97	1620000	99.29
	Grand Total (A+B+C)	NA	2727.87	NA	3178.19	NA	NA	2863.76	NA	2353.33	NA	2303.532	NA	2425.16

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