AmbujaNeotia

THE NEOTIA UNIVERSITY

ज्ञानम् आत्म प्रदीपाय

Practical Manual
Commercial Sericulture (ELP)
(EL-AGP 812)




Prepared by:
School of Agriculture & Allied Sciences
The Neotia University

PREFACE

The practical manual for the B. Sc. (Agriculture) course "Commercial Sericulture (ELP)" has been compiled following the prescribed syllabus of the revised ICAR Fifth Dean Committee. The manual would provide basic knowledge about the mulberry, silkworm rearing or sericulture to the undergraduate students of Agriculture. I am confident that this practical manual would be helpful as a handy reference to understand the basic principles and methodology of the experiments. It is my prerogative to thank Prof. Swapan Kumar Mandal, former-Head and Professor, Department of Agricultural Entomology, Bidhan Chandra Krishi Viswavidyalaya (BCKV), Mohanpur and Professor, School of Agriculture and Allied Sciences, The Neotia University (TNU) for his valuable support and guidance during the preparation of this manual.

Dr. Snigdha Samanta

CONTENTS

Sl. No.	TITLE	Page No.
	Introduction to Sericulture	1-5
1.	**Business idea: Propagation Of Elite Clones of Mulberry**	**6-12**
	Mulberry crop production technology	6-9
	Method of harvesting and preservation of Mulberry leaves	9-11
	Yield Estimation	11
	Preparation of Balance sheet	12
2.	**Business idea: Silkworm Rearing for Disease free Laying (DFL)**	**13-25**
	Pre-requisite for Rearing	13-15
	Method of preparation of disinfectant solution	15
	Process of disinfection	15-16
	Collection and transportation of silkworm eggs	17
	Surface sterilization of Dfls	17
	Egg handling, storage, incubation	17-18
	Black boxing-I	18
	Black boxing-II	18
	Exposure of eggs to light for Hatching	19
	Brushing	19-20
	Chawki Rearing	20
	Preparation of Chawki Bed	20-21
	Feeding frequency	21
	Bed Cleaning	21
	Bed Spacing	21-22
	Maintaining of ideal Temperature condition	22-23
	Care during Moulting	23
	Process of Moulting	23-24
	Late age silkworm rearing	24
	Larval protection	24
	Keeping records till 5^{th} instar larva	24-25
3.	**Business idea:** Quality Cocoon Production	
	Cocoon Harvesting	26-28
	Deflossing of Cocoon	28-29
	Sorting of Cocoon	29
	Assessment of Cocoons	29
	Calculation of SR ration	30
	Preparation of Balance sheet	30-31

4.	**Business idea: Reeling and processing of raw silk**	**31-33**
	Process of Reeling	31-32
	Preparation of Balance sheet	33-34
5.	**Business idea: Silkworm bye products**	**35**

INTRODUCTION TO SILKWORM

Objective: To familiarize the students with sericulture

Definition –

Sericulture is the process of cultivating silkworms and extracting silk from them. The caterpillars of the domestic silkmoth (also called 'Bombyx Mori') are the most commonly used silkworm species in sericulture. Other types of silkworms (such as Eri, Muga, and Tasar) are also cultivated for the production of 'wild silks.

Systematic position of Mulberry Silkworm –

Kingdom: Animalia

Phylum: Arthropoda

Subphylum: Mandibulata

Class: Insecta

Subclass: Pterygota

Division: Endopterygota

Order: Lepidoptera

Suborder: Bombycoidae

Family: Bombycidae

Genus: *Bombyx*

Species: *mori*(L)

What are the different species of silkworm suitable for commercial rearing?

In India man is being benefited by four types of silkworms. They are, Mulberry, Tasar, Eri and Muga silkworms. Except mulberry silkworm, all others are wild types. Mulberry silkworms is a domesticated variety which has been exploited for over 4000 years. Generally, the term silk refers to Mulberry silk, because it contributes to 95% of world silk production. All the strains or races reared at present belong to the species *BOMBYX MORI*(L).

SERICULTURE IN INDIA

India is one of the 58 sericulture industries. It has the distinctive distinction of being the sole country within the world manufacturing all the four kinds of silk, namely mulberry, tasar, eri and Munga. No one really knows when sericulture came in India, but it existed in the Ganga Brahmaputra belts from time immemorial. The word saree is derived from Sanskrit word shatto or Shatika, which was later called as Shadi or sari. While some believe that it is derived from sares meaning silk.

According to one view all domesticated forms of mulberry came from China. A Chinese princess got married to a king in Tibet in 140 BC. She brought some eggs of silkworm and

some mulberry seeds hidden in her headdress. According to another view by N.G. Mukarjee, all mulberry insects originated somewhere on the slopes of Himalayas on the skirt of Mount Everest, from where they spread to wormer regions.

The chronology of events regarding the history of sericulture in India

- **4000 B.C.** Ericulture exsisted even before the Aryans migrated to India. It has been almost a prerogative to the tribal of Northeast India.
- **1400 B.C.** Traces of tasar silk have been excavated from a burial mound in an urn in Nevassa in Maharashtra i.e., even before China started producing tasar around 100 A.D.
- **321-296 B.C.** Kautilyas 'arthashastra'of Chandragupta's time reveals that patrona(variety of silk) was obtained from the country of magadh pundrya and subarakundya. Silk obtained from Naga trees was yellow and that obtained from Artocarpus lakooch vern. Lokucha was of the color of wheat. Silk obtained from M musops elengi vern. Vakula was white and that obtained from Ficus bengalensis and Ficus religiosa vern. Veta was the color of butter. Arthashastra also made distinction between cultivated and wild varieties of silk. Theophillareligiosae (wild mulberry silkworm) still feeds on mulberry, Artocarpus lakoocha and ficus religiosa.
- **150 B.C.** Reshma shawls and woven silks were quite popular in king's courts of Kashmir, which was also known for its wonderfull mulberry trees.
- **58 B.C.** During regin of Kanishka raw silk was exported from India to Rome
- **629-645A.D.**The Harisharita written by Bana bhatt reveals that during the Hiun Tsang's visit to India, great monarch Bhaskara of pragiyotishpura sent silk cloths of all varieties produced in Kampura, Assam to king Harsha of Kanyanubja. The gift included chinapatta (figured textile), kauseya (textile from kosaor cocoon), khsauma (fine silk) and jattipatka (woolen silk). During this period the people knew that art for the production of silks from wild silkworms such as Muga, Deomuga, Kotkarimuga etc., the caterpillers which feeds on Litsia salicfolia, L. citrate vern. Mejankari and L. champaca vern chapa.
- **1526-1857 A.D.** Sericulture industry flourished during the mughal period.
- **1603-1641 A.D.** During the reign of Prathap singh in Northeast India, the golden hued Muga silk, the costliest and most precious of all silks.
- **1869 A.D.** Maharaja Ranabir singh built 127 rearing houses in Kshmir state.
- **1878 A.D.** Sericulture industry received a setback due to pebrine disease.

- **1900-1930 A.D.** Britishers (East India Company, which came to India 6 filatures in 1900) and the industry once again started prospering. They also set up in Patna. Many silk centres like filatures were also set up at Patna. Many silk centres like Maldaha, Murishidabad etc., came up.
- **April 1949 A.D.** A statutory body called Central Silk Board working under the administrative control of Ministry of textiles, Government of India was established according to Act no. LXI of 1948 was passed by parliament.

Why Sericulture?

High employment potential

- 60 lakh persons are engaged in various sericulture activities in the country
- It is estimated that Sericulture can generate employment at 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 different trade generates this sort of employment, especially in rural areas, hence, sericulture is used as a tool for rural reconstruction.

Provides resonance to village economies

About 57 % of the gross value of silk cloths flows back to the cocoon growers with share of revenue 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.

Low gestation, high returns

- 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 solely six months to grow for commencement of silkworm rearing. Mulberry once planted can maintain supporting silkworm rearing year after year for 15-20 years looking on inputs and management provided.
- Five crops will be taken in one year under tropical conditions.
- By adopting stipulated package of practices, a farmer can attain net income levels up to Rs.30000 per acre per annum.

Women friendly occupation

Women constitute over 60 % of those employed in down-stream activities of sericulture in the country. This is conceivable as a result of sericulture activities ranging from mulberry garden management, leaf gathering and silkworm rearing is a lot effectively concerned by the women folk. Even silk reeling business together with weaving is mainly supported by them.

Ideal program me for weaker sections of the society

- Sericulture can be practiced even with very low land holding.
- Acre of mulberry garden and silkworm rearing will support a family of 3 while not hiring labour.
- Features like low gestation, high returns facilitate sericulture a perfect program for weaker sections of the society.
- Vast tracts of primarily forest based Tasar food plantations on the market in the country, if judiciously exploited for rearing Tasar silkworms, can offer supplementary gainful employment for tribals.

Eco-friendly activity

- AS a perennial crop with decent foliage and root-spread, mulberry contributes to soil preservation and provides green shelter.
- Waste from silkworm rearing are often recycled as inputs to garden.
- Dried mulberry twigs and branches are used as fuel instead of firewood and thus scale back the pressure on vegetation/forest.
- Being a labour intensive and largely agro-based activity, involvement of smoke-emitting machinery is nominal.
- Developmental programs initiated for mulberry plantation are mainly in upland areas where un-used cultivable land is made productive.
- Mulberry may also be cultivated as intercrop with various plantations.
- Mulberry being a deep-rooted perennial plant are often raised in vacant lands, hill slopes and watershed areas.
- Currently, solely about 0.1 % of the arable land in the country is under mulberry cultivation.

Satisfies equity concerns

- Advantages of sectorial value-addition primarily accrue to rural households. As the end-product users are largely from the upper economic sets, 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.

Business Idea 1: Propagation of Elite Clones of Mulberry

Objective: To acquaint with agronomic practices followed for commercial cultivation of mulberry plants and the common varieties grown.

Mulberry Crop Production Technology

Mulberry (Morus spp.) is a perennial, deciduous, deep-rooted, fast-growing and high biomass producing plant. Mulberry can be grown in both tropics as well as in temperate regions. It can be cultivated in different soil types and can be raised in both rainfed as well as in irrigated conditions. It is comparatively resistant to environmental fluctuations. There are over 20 species of mulberry, of which four are common and popular species in India, namely, Morus alba, *M. indica*, *M. serrata* and *M. latifolia*. They belong to family Moraceae. Cultivation of mulberry plants is called Moriculture.

❖ **Soil:** Mulberry is a deep rooted, perennial, hardy crop. Clayey loam to loam soils are much preferred. Soil pH 6.5 to 7.0 is very ideal. If soil is acidic (below pH 7.0) lime is added. If soil is alkaline (above pH 7.0) gypsum is added.

❖ **Temperature:** Preparation of nursery beds 20 to 30°C temperature is suitable for mulberry plant growth.

❖ **Rainfall:** Optimum rainfall required 1000 – 1500 mm.

❖ **Nursery raising:** Season: June-July and November-December in the year.

❖ **Varieties:** The most popular and superior mulberry varieties used in India for silkworm rearing are V1, S36, S13, S54, S146, S1635, TR10, S1 and K2 in plain subtropical area and Kosen, Ichinose, Goshoerami and KNG in hill temperate area of Kashmir and parts of Himachal Pradesh.

❖ **Land Preparation:** Select elevated, flat, well drained light textured, deep loamy or clay loamy soil. Give deep digging/ploughing two times in both the directions. Give a fine tilt after 10-15 days of digging/ploughing. Prepare the bed size of 300 x 120 cm (length and width). Provide drain channels of 25-30 cm width and 15-20 cm deep. Apply 20 kg FYM/ bed.

❖ **Preparation of cutting:** Mulberry is propagated either by seeds, root- grafts or stem cuttings, the last one being most common. Use eight months old twigs as planting material. Prepare cuttings of 15-20 cm length and 1-1.5 cm diameter having 3-4 active buds Store the cuttings wrapped with wet gunny cloth in shade. Sprinkle water if transplantation is extended/postponed.

❖ **Planting Techniques:** Provide 20 cm spacing between rows and 8 cm between cuttings. Make holes with a stock in the soil to insert cuttings. Plant the cutting in slant position.
Press the soil firmly around the cuttings. Provide mulching with dried mulberry twigs, thatch etc.

❖ **Maintenance of mulberry nursery:** Irrigate the nursery once in a week during dry period. Keep the nursery bed weed free.

❖ **Fertilizer application to nursery:** After 55-60 days of growth, apply 500 g ammonium sulphate or 250 g urea dissolved in the irrigation water for each bed.

❖ **Disease and pest management in the mulberry nursery:** Spray 0.1% DDVP against Tukra. Spray 0.1% Bavistin against powdery mildew.

❖ **Transplanting:** After three to four months, saplings become ready for transplanting. Irrigate the nursery beds prior to transplanting. Uproot the saplings with a spade or pickaxe. Sprinkle water in case of preservation for shorter duration. Pack the saplings in wet gunny cloth to avoid desiccation of roots if long distance transportation is required.

❖ **Plantation in the main field:** Season: June - September (During monsoon).

❖ **Land preparation:** Prepare the land by ploughing and cross ploughing with power tiller or tractor during pre-monsoon showers to a depth of 30 cm.

❖ **Preparation for paired row plantation:** Paired rows system of (150 cm + 90 cm) × 60 cm spacing is recommended. In this type of plantation 13,887 plants can be accommodated in one hectare of land. This system of spacing facilitates adoption of mechanization for intercultural operations using tractor/power tiller. Transplant the saplings during monsoon and press the soil firmly around the sapling. Mulch the base of the sapling with dry leaves/ thatch/mulberry twigs. Water the sapling immediately after transplanting.

Field preparation for mulberry saplings

❖ **Crop management practices:** Give a light hoeing after one month of plantation to eliminate weeds and for aeration. Give two more weeding and light digging at an interval of one month. Irrigate the plants as and when necessary. Apply FYM @ 25 MT/ha/year. From 2nd year onwards apply NPK @ 350:140:140/ha/year. Five crops can be taken from V1 or S36 variety/year.

❖ **Pruning:** Certain branches of mulberry are periodically cut to give a proper shape and size to the plant, in order to increase the leaf yield and its feeding value. This is known as pruning.

❖ **Types of Pruning:** Based on the height of the plant from ground level where it is cut, there are 3 types of pruning. i. Bottom pruning or low cut pruning: It is widely practiced in Japan. Plant is cut at a level of 30 cm above ground level during June-July months.

ii. Middle pruning or medium cut pruning: Plant is cut at a height of 0.5 to 1.5 m above ground level during December–January months. Large number of branches grows, but only 3-4 on the upper part are retained. iii. Top pruning or high cut pruning: Plant is cut at a height of more than 1.5 m above ground level. Leaf quality is poor with low moisture. Harvesting difficult due to more height. Less damage due to floods, but more susceptible to pests, diseases and winds. Mulberry varieties for various agro-climatic and soil conditions

➢ **Victory 1:** It is popularly known as V1. Leaves are thick, succulent, large, entire and ovate with truncate base. Leaves are smooth and glossy. It has got good agronomic characters like high rooting ability, fast growth and high yield. Under irrigated conditions, with recommended package of practices it yields about 60 MT/ha/year. Bioassay and chemoassay tests indicated the superiority of this variety for silkworm rearing.

➢ **S36:** Leaves heart shaped, thick, light green with glowing nature. Leaves have high moisture and more nutrients. Branches grow straight. It yields 35-45 mt/ha/year under irrigated conditions. Because of its high succulence and nutritive quality, it is recommended for young age silkworm rearing.

➢ **S13:** Leaves dark green, succulent and good quality. Branches grow bushy and straight. Suitable for chawki and late age worms. It yields 12–15 mt/ha/year under rainfed conditions.

➢ **S34:** Fast growing has deep and extensive root system and it adopts well under soil moisture stress conditions. Leaves are medium to large, unlobed and dark green in colour with high moisture content and good retention capacity. It yields about 12–15 mt/ha/year under rainfed conditions. The variety is recommended for black cotton soils.

➢ **Sahana:** Evolved from cross-pollinated hybrids of K2 x Kosen during 2000. It is characterized by medium branching, fast growing, slightly spreading, pinkish-grey branches with short internodes. Leaves are large, unlobed, thick, cordate, glossy and dark green. The variety performs well under limited shade with improved leaf area. As intercrop with coconut plantation the variety can produce 25–30 mt leaf/ha/year under irrigated conditions.

➢ **AR12 (Alkaline tolerant):** Evolved from cross-pollinated hybrids of S-41 (4x) x Ber. C776 (2x) during 2000. Leaves are unlobed, large, cordate, thick, dark green with slightly rough surface. The variety is suitable for alkaline soils with pH range of 8.0 – 9.4 with a yield potentiality of about 25 mt/ha/year in alkaline soils under irrigated conditions.

METHOD OF HARVESTING AND PRESERVATION OF MULBERRY LEAVES

Leaf Harvesting Leaf harvested during afternoon contain less water and more of carbohydrates due to active photosynthesis and transpiration taking place in day time and such leaves wither very quickly. Hence, mulberry leaves should be harvested during cooler hours in the early morning hours is recommended to avoid moisture loss in leaves during harvest and transportation.

1. Leaf picking: Leaves are picked individually from main stem with petioles. At the same time, terminal buds are nipped off so that lateral shoots develop rapidly. It requires more labour and leaves wither quickly.

2. Branch cutting (Batchi system in Kashmir): The entire branch is harvested and used to feed worms after third moult directly. It requires less labour and leaves retain succulence for longer period. 3. Whole shoot harvest: The branches are cut to ground level by bottom pruning. The entire shoot is fed to leaves. Shoots are harvested at 10-12 weeks interval and 5-6 harvests are made per year. Shoots of 4–5 ft height are cut with the help of sharp sickle and bundled with 10–12 kg weight, convenient to carry them to shoot preservation room.

Harvesting of Mulberry leaves

Preservation of harvested leaves and shoots

❖ **Leaf preservation:** The harvested leaves should be collected in wet gunny cloth-covered baskets and transported to a leaf chamber/room carefully in well-ventilated condition. Leaf should be preserved in a separate room or leaf chamber made up of wood with sufficient number of ventilators and covered with wet gunny cloth. This helps in maintaining leaf quality and moisture in leaves. Leaves can also be stored in a separate ventilated room with well-disinfected floor. Leaves should never be preserved on heaps. This will increase the humidity. Leaves scattered on floor should be frequently sprinkled with water and tilted up and down in summer. Always fresh leaves are recommended to feed the worms. Longer the preservation, lesser the moisture and the nutrition, hence temperature, humidity and moisture contents in the storage place should be 20°C and 90% of relative humidity and cool, clean with frequent watering. Chawki mulberry leaves can be stored in a mud pot, which is placed in the moist sand and mouth of the pot must be covered with wet cloth. Also, chawki mulberry leaves can be stored on a flat moist sand bed covered with wet and clean white cloth.

❖ **Shoot preservation:** Shoots are properly wrapped with wet gunny cloth and preserved vertically in upward direction. Floor of rearing room should be washed with 1% bleaching solution daily before preservation of shoots. Separate footwear should be used for leaf chamber, which is disinfected daily with soap solution. While transporting from mulberry garden to preservation room, shoots should be covered with wet gunny cloth or polythene sheet to avoid water loss in leaves.

Observation:

Yield Estimation

Cultivar/Variety	Yield (kg/plant)

Preparation of balance sheet

Objective: To learn the process of calculation of cost of production.

Procedure: Collect all the data related to all inputs required, cost of labour, collection of data and market study for cultivation of Mulberry.

Observation: Calculate the cost of cultivation, Net profit and calculation of B: C ratio.

Sl.no	**Items**	**Quantity**	**Rate (Rs)**	**Amount (Rs)**
1.	FYM			
2.	Labour			
3.	Fertilizers			
4.	Planting material			
5.	Irrigation			
6.	Miscellaneous			
Total cost of Cultivation (Rs.)				
Yield (Rs.)				
Net Profit (Rs.)				
B:C Ratio				

2. Business idea: Silkworm Rearing for Disease free Laying (DFL)

Objective: To acquaint with techniques and procedure for commercial rearing of silkworm

Silk is produced by silkworm for spinning its cocoon. It is a fibrous protein, which is light in weight, soft to touch, has high durability, natural sheen and integral affinity for dyes. All these exceptional characteristics of silk make this fibre "Queen of textiles". In India, sericulture is an age-old practice and has mingled with the culture and life of Indians.

STEP 1: PRE-REQUISITE FOR REARING

Mulberry silkworm rearing, being completely domesticated, demands specified environmental conditions like temperature (24-28ºC) and relative humidity (70-85%). It is therefore necessary to evolve measures for economic cooling through selection of proper material for wall and roof fabrication, orientation of building, construction method, design, etc. Further, enough space must be available to carry out leaf preservation, chawki rearing, late age rearing and moulting. It should also be convenient enough to conduct effective cleaning and disinfection. The rearing house should have-

1. Separate house is ideal for rearing of silkworm
2. The rearing house should have sufficient number of windows to permit cross ventilation.
3. Provision should be made to make it air tight for proper disinfection.
4. Rearing house has to be built in such a way to provide optimum temperature of 24-28º C and RH of 70-85% for the growth of silkworm at minimum operational cost.

Rearing Appliances of Silkworm:

Being a rural-based agro-industry, appliances used in sericulture are mostly made of cheap and locally available materials and thus, vary from place to place. Moreover, researchers of CSB and other private rearers have developed many devices suitable for silkworm rearing. Here, appliances, required for shelf rearing, will be mentioned.

Shelf Rearing Appliances:

(i) Tray stand:

This bamboo-made or wooden stand is used to support the rearing trays. It has a height of 2.5 m and has 10-12 cross-bars at a distance of 0-1.5 m to accommodate 10-12 tiers of rearing tray.

(ii) Rearing trays:

These are circular bamboo trays (138 cm dia x 6.5 cm depth) or light wooden rectangular trays (0.7-0.9 m x 0.9-1.2 m), each of which can accommodate a large number of young larvae. The trays are often coated with cow- dung paste mixed with formalin, though this practice often invites many disease-causing agents.

(iii) Ant wells:

Enamel / Aluminium bowl or stone / concrete blocks (Fig. 3.2) are used as ant wells which are kept filled with water except the central elevation on which legs of tray stands are placed. It prevents ants from crawling up the stand and harming the worms.

(iv) Paraffin paper:

To avoid evaporation of moisture and keep humidity on the rearing tray, pad of paraffin-coated papers are kept on rearing bed of young silkworm. Polythene sheets, dried banana leaves may also be used instead of paraffin-paper.

(v) Foam rubber strips:

To maintain the required humidity, sometimes thick foam pads soaked in water are placed all around the bed. Thick folding of newsprint paper or blotting paper soaked in water can also be used in place of foam strips.

(vi) Chop sticks:

Forceps-like device, made of two thin bamboo sticks, joined at one end by thread is used to pick worms.

(vii) Feather:

Soft, white feathers are used for brushing newly hatched larvae from the egg card to rearing tray and to spread the young worms during spacing.

The size of the rearing house depends upon the quantum and type of rearing. A floor area of 400 sq. ft. can provide rearing space for 100 dfls (dfl: Disease Free Laying; 1 dfl = 500 larvae).

Observation:

Conclusion:

STEP 2: METHOD OF PREPARATION OF DISINFECTION SOLUTION

Disinfectant is safe and efficient, to animal without teratogenesis, mutagenesis, carcinogenesis, belongs to the environmentally friendly bactericide to people, animal, ecological environment security, is conducive to the protection of the medicine person of spraying self. Disinfection of rearing house and appliances should be made twice before rearing that with 5% bleaching powder (immediately after the completion of previous crop).

Observation:

Conclusion:

STEP 3: PROCESS OF DISINFECTION OF REARING HOUSE

It is the most important operation that to be carried out prior to the commencement of rearing. Disinfection of everything including rearing places is carried out by physical, chemical or radiation methods.

(i) Physical methods:

These are cheap, convenient and easy to operate.

(a) Sunlight:

Drying of rearing appliances in sunlight can cause disinfection. However, sun drying cannot be carried out during winter and rainy seasons, and some appliances are likely to be damaged by exposure to sunlight,

(b) Steam:

Disinfection by steaming may be used for rearing room and some appliances (not made of bamboo or wood). However, initial cost for installing the steaming apparatus like boiler and pipeline is high.

(c) Hot air:

It is also a good sterilising method but cannot be used in routine sericulture because of its production cost.

(ii) Chemical method:

The most commonly used disinfection method in sericulture is chemical method. Chemicals generally used are non-toxic to man and animals, have broad spectrum activity, stable and readily mixable with water and fair in cost.

Most frequently used chemicals include chlorine as chloramine, iodine as iodophores, phenol as cresol and hexachlorophene, formaldehyde as formalin (2%), bleaching powder, etc. These are used as spray or fumigant. Precautions should be taken during and after the applications of such chemicals.

Observation:

Conclusion:

STEP 4: COLLECTION & TRANSPORTATION OF SILKWORM EGGS

The disease-free eggs are collected in wet handbags with proper aeration in early morning or in late evening. Trans-portation may be done during aestivation period, hibernation or post-hibernation period or pre--incubation period. Management of Silkworm/Larvae.

The transportation of eggs plays an important role in the development of embryo and successful crop harvest. The disease-free eggs are collected in wet handbags with proper aeration in early morning or in late evening. Transportation may be done during aestivation period, hibernation or post-hibernation period or pre-incubation period.

Observation:

Conclusion:

STEP 5: SURFACE STERILIZATION OF Dfls.

- Egg should be dipped in 2% formalin solution for 10-15 minutes but not less than 10 minutes.
- In case of sheet-egg, the sheets should be dipped in 2% formalin solution for 10 minutes and wash in running water and dry in shade.
- In case of loose eggs, they have to be taken out from the container, transferred into a cloth bag and dipped in 2% formalin solution, wash and dry in shade.

Observation:

Conclusion:

STEP 6: EGG HANDLING, STORAGE, INCUBATION

The most important as well as precarious stage of sericulture is the production of healthy and disease-free eggs and it plays a vital role on which the success of the industry depends. Silkworm eggs are also called seeds and for sericulture purpose the eggs are classified into two groups, viz., Reproductive seed and Industrial/Commercial seed.

STEP 7 : BLACK BOXING, I

- **Irrespective of rearing seasons,** black boxing should be done when 80% of eggs reach 'Blue' stage to ensure uniform hatching of eggs (>90%)
- Temperature of 25C and 75-80% humidity should be maintained during Black Boxing.
- Black Boxing is required 24-36 hours.
- When plastic trays are used, they can be piled up one over other and the whole stand is covered with black cloth.
- For maintaining the optimum humidity, the cloth should be made wet or kept dry as per the requirement.

Observation:

Conclusion:

STEP 8: BLACK BOXING, II

- **Irrespective of rearing seasons,** black boxing should be done when 80% of eggs reach 'Blue' stage to ensure uniform hatching of eggs (>90%)
- Temperature of 25C and 75-80% humidity should be maintained during Black Boxing.
- Black Boxing is required 24-36 hours.
- When plastic trays are used, they can be piled up one over other and the whole stand is covered with black cloth.
- For maintaining the optimum humidity, the cloth should be made wet or kept dry as per the requirement.

Observation:

Conclusion:

STEP 9: EXPOSURE OF EGGS TO LIGHT FOR HATCHING

On the day of hatching, the eggs are exposed to diffused light from a tube light, bulb or natural day light inside the incubation room. The eggs when exposed to light should be provided with optimum humidity and temperature. Hatching of larva is completed within 2.5 hours.

Observation:

Conclusion:

STEP 10: BRUSHING

i. Brushing of sheet eggs

- The ideal time for brushing is 8-9 A.M.
- After attaining uniform hatching, the tender mulberry leaves of suitable quality are selected, chopped at a size of 0.5 cm * 0.5 cm square and sprinkled in a thin layer on the newly hatched larvae.
- After 30minutes the egg sheets are turned upside down to transfer the worms on the rearing tray and the 1st feed is given.
- The use of chop sticks or feathers for stretching the rearing bed or making the rearing bed is advised.

ii. Brushing of loose eggs

- Cotton or nylon net with proper mesh size should be spread on the worms before giving 1st feeding to the newly hatched larvae.
- Wet foam pad should be kept around the bed and the bed must be covered with another paraffin paper.
- Before the second feed, all the larvae which crawled up on the upper net are transferred to a rearing tray with a bottom paraffin paper.
- Then 2nd feeding and proper bed spacing should be given.

Observation:

Conclusion:

STEP 11: CHAWKI REARING

From hatching to its full-grown stage, the silk worms pass through five instars and the worms up to stage two are called young age worms or chawki. As they are susceptible to infections and vulnerable to adverse weather conditions, special care is required for rearing of chawki. Hence, it is advisable to obtain silkworm reared under controlled conditions in separate chawki rearing centers. The package of practices for chawki rearing is entirely different from late age rearing.

Observation:

Conclusion:

STEP 12: PREPARATION OF CHAWKI BED

The rearing bed should be provided with wet foam pad in all the four sides and covered with paraffin paper to complete the operation of brushing.

- Tender mulberry leaves with 75-80% moisture and high nutrient content (protein 27%, carbohydrates 11%) are ideal for young age silkworms.
- A separate mulberry plot/garden is preferable for this purpose which should be provided with high quality of FYM (40 tonnes/ha/yr.) and NPK is 236:180:112 kg/ha/yr.
- S1635 variety is suitable for chawki rearing.
- Chawki plot should be irrigated regularly to enhance moisture content of leaf.
- Leaves should be harvested during cooler hour of the day and preserve loosely in wet gunny cloth.
- During dry seasons water should be sprinkled on the gunny cloth.
- Excess harvesting and long preservation of leaf should be provided.

- Since the worms are tiny in size, chopped leaves are spread uniformly on the worms in rearing bed so that the worms can have easy access to the leaves for feeding.
- It also helps in loosening and spreading the bed when the bed is required to be dried prior to feeding and also at moulting.

Observation:

Conclusion:

STEP 13: FEEDING FREQUENCY

- **Four times feeding** per day at 6 am, 10 am, 4 pm & 8 pm should be given during both favourable and unfavourable seasons to avoid quick withering of cut leaves.
- **Paraffin paper should be removed half an hour** before feeding.

Observation:

Conclusion:

STEP 14: BED CLEANING

- Remove the unhealthy larvae, if any and put them into 2% bleaching powder in 0.3% slaked lime solution.
- Don't spill the bed refuse on the floor of the rearing room while cleaning the bed.

Observation:

Conclusion:

STEP 15: BED SPACING

- Through optimum spacing at every stage of rearing, starting from brushing of the worms, vigorous growth, robust health and uniform development of the entire batch of worms are ensured.
- To ensure maximum development of all the larvae uniformly, spacing is required to be increased systematically at every stage of growth of chawki worms.

- It helps to keep the bed thin (less than ½ inch in height) and this assists in the drying of beds prior to every feeding.
- Thick beds that are not dried easily tend to build up humidity beyond 90% which leads to the outbreaks of diseases.

Instar	Bed Size (sq cm)	
	Multi * Bi	Bi*Bi
I	6-18	8-21
II	18-54	21-65

Observation:

Conclusion:

STEP 16: MAINTAINING OF IDEAL ENVIRONMENTAL CONDITION

Temperature:

- Optimum temperature for 1st instar is 27-28 C and for 2nd instar is 26-27 C.
- During winter crops, temperature should be increased by using electric heater or smoke less chula.
- In low temperature, worms do not feed properly for which they become susceptible to diseases and prolonged larval period also, increase wastage of leaf.

Humidity:

- 85-90% humidity should be maintained during chawki rearing.
- During dry seasons paraffin paper as bottom and covering sheets in the rearing tray along with wet foam pads around the rearing bed should be used to enhance humidity. Humidifier can also be used.

- ❖ During rainy seasons i.e. June-July and Aug.- Sept., lime may be sprinkled in the chawki rearing room for absorbing extra moisture. Bottom paraffin paper should be changed in each instar.
- ❖ Windows and doors should be opened as per need to facilitate entrance of fresh air for reducing humidity.

Observation:

Conclusion:

STEP 17: CARE DURING MOULTING

1. Ensure good ventilation and dry condition in the rearing house during moulting period.
2. Spread the bed gently soon after the worms settle for moult and apply slaked lime powder uniformly over the bed to ensure drying of bed.
3. Avoid high fluctuation of temperature and humidity as well as strong wind and bright light.
4. Resume feeding when 95% of worms come out of moult.

Observation:

Conclusion:

STEP 18: PROCESS OF MOUNTING

To obtain such quality cocoons, mounting the silkworm larvae at the appropriate time and good quality mountages are essential. In the fifth instar on seventh day silkworms enter into maturation and stop feeding and begin to search place to build the cocoons. Such larvae are picked immediately and mounted on to the mountages. Care should be taken that the number of larvae on mountages must not exceed the capacity of each mountage. When the larvae are in spinning stage, the room temperature of 24°C and 60-70 % of relative humidity along with good aeration facility are to be provided. Rotary mountages are recommended for the

production of better-quality cocoons. About 35 sets of rotary mountages are required for mounting worms of 100 dfls. For hanging rotary mountages, a separate mounting hall or verandah is required.

STEP 19: LATE AGE SILKWORM REARING

Rearing of late age worms begins from third instar. These worms are voracious feeders.

STEP 20: LARVAL PROTECTION

- Young age worms are highly susceptible to various diseases. So preventive measured should be taken.
- For prevention of diseases, dusting of bed disinfectant should be done after each moult.
- After dusting rearing bed should be covered with paraffin paper for 30 minute before feeding.
- 350g/100 dfls bed disinfectant is required in the 1^{st} & 2^{nd} instar.
- Freshly prepared bed disinfectant should be used for better result.

Observation:

Conclusion:

STEP 21: Keeping records till 5th instar larva(i)

Instar	Days	Remarks

STEP 22: Keeping records till 5th instar larva (ii)

Instar	Days	Remarks

3. Business idea: QUALITY COCOON PRODUCTION

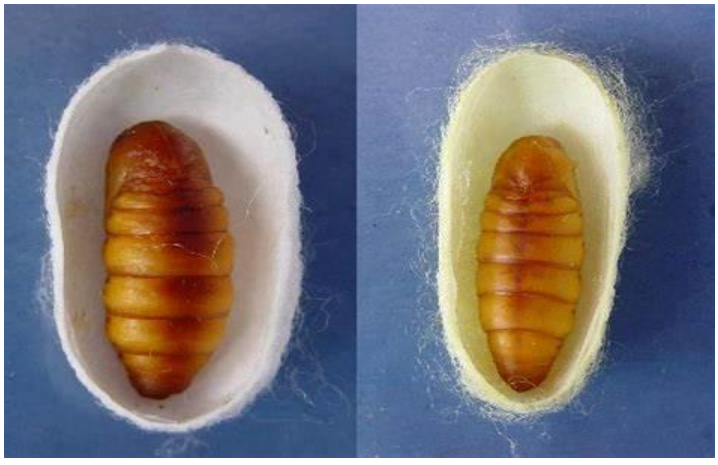
Objective: To acquainted with techniques and procedure for cocoon production.

In the previous units, we have learnt about the techniques of handling of silkworm eggs, rearing of silkworm larva, identification of mature (ripen) larva and placing of the mature larva in the spinning trays (mountages). When the mature larva is placed in the mountages, it will spin a cocoon by ejecting a silk filament from its silk gland through an opening (spinneret). Silk filament is protein in nature, which hardens in contact with the air. You know that mature silkworm larva will take 3-4 days to spin a cocoon. After complete ejection of silk and formation of the cocoon, metamorphosis takes place and the larva transforms into pupa. In between, there is pre-pupal stage. This transient phase is very delicate. Normally, within ten days, the pupa again undergoes metamorphosis and emerges as a moth by piercing the cocoon. Now the question comes how to handle the cocoons and what to do with cocoons? Let us try to learn how to handle the cocoons.

COCOON HARVESTING

A. Time of harvest:

Harvest is commonly used to mean gathering or collection of ripen crops, especially in agricultural produce. In sericulture, harvest signifies to the collection and gathering of produced cocoons from spinning tray or mountages. For completion of spinning and metamorphosis, about 5-6 days are required and you have to allow the larvae for this process. While harvesting, it may also be considered that during summer, the process is faster, whereas, in cooler months, it is slower. After pupation, when the integument of the pupa turns brown and hard on the 5th day the cocoons may be harvested. The safest method is checking the condition of pupae by slit open a few pupae. Premature collection of cocoons or harvesting may lead to loss of silk content of the cocoons due to incomplete spinning or killing the delicate pre-pupa or



Pupa

pupa within the cocoons. Killing of pre-pupa or tender early pupa inside the cocoon will lead to stained cocoons, rendering it unfit for reeling.

To avoid this, harvest cocoons at 6th day after completion of full 5 days in mountages, counted from the last day of mounting. The pupa will be hard and cocoon shell will be dry. This condition will be suitable for safe handling and transportation of cocoon. Cocoons release moisture even after completion of spinning. Delayed harvest will lead to weight loss of cocoons. So, it is important to stick to the time of harvest.

B. METHODS OF HARVEST

You might have realized the importance of timely harvest of silk cocoons. Now, the question comes how will you harvest?



Harvesting of cocoon from chandrika by hand

Methods for harvesting of silk cocoons varies, depending upon the mountage (spinning tray) used. Whatever the methods of harvest, first you remove litters and left-over of leaves, dead or un-spun larva, naked pupa (without cocoon), flimsy and melted cocoons from the mountage.

Flimsy and melted cocoons may spoil the good cocoons by spilling stain. Spiral bamboo mountage (Chandrika) is most commonly used in our country. You may harvest the cocoons from Chandrika by hand, simply by moving your fingers in between the ridges. In case of plastic collapsible mountages, you may harvest manually by hand picking. In the rotary card board mountages, harvesting by hand is rather difficult and time consuming. You can use a wooden harvester for quick harvesting. It has two parts. First one is a wooden frame on which cardboard mountage can be fixed. Another is pusher, made up of wooden pegs, that fits with the hole of mountages. After removing dead worms, flimsy and stained cocoons, fix cardboard mountage on the harvester. Then, place the wooden pusher on the holes and push gently so that cocoons come out of cardboard holes. Now, you may collect the cocoons by hand by folding the mountages

Placing of mountages on harvester collection of cocoon

In order to ease the process, some machines are developed by CSR&TI, Mysore for harvesting and deflossing the cocoons, the details are as follows:

a) Cocoon Harvester: It is made up of iron or wood. It consists of two parts and is used for harvesting cocoons from rotary mountages. Cardboard mountages are inserted into the wooden frame and cocoons are pushed out using the pusher made of the same size as the holes of the mountages

b) Cocoon Deflosser: Hand operated and motorised cocoon deflossing machines of different capacity are available for fast deflossing of the cocoons. The motorised machines have capacity to defloss100 kg cocoons per hour.

After harvesting, spread the cocoons in trays with maximum of two layers of cocoon. Heaping of cocoons may lead to accumulation of moisture and heat and ultimately melting of cocoons.

Observation:

Conclusion:

Deflossing of cocoon

After harvesting of cocoons, you will find that the cocoons are covered with a soft and loose layer of silk filaments, which is called floss. Removing of the flossy layer from the cocoon is called Deflossing. Deflossing is a pre-requisite for extraction of silk (Reeling). During the process of reeling, floss is removed by brushing. In this process, some portion of reelable silk also goes as waste. Deflossed cocoons minimize the loss during reeling. Cocoons used for egg production are also deflossed for assessment of quality and easy emergence of moth.

The cocoons can be deflossed m. But, it is time consuming and labour intensive. Presently, many manuals or power operated deflossing machines are available. These machines are quite efficient for all kinds of cocoons. Cost of deflossing by machines is about 40-50 times cheaper than manual. In the market, deflossed cocoons will fetch higher price as the buyer can assess the quality and silk content very quickly.

Sorting of cocoon

After deflossing, if you spread and look into cocoons, you will find most of the cocoons are with a particular shape and size because the shape and size are inherited racial or genetic characters, even though you will find some odd shaped and defective cocoons. Removal of odd shaped and defective cocoons from the lots is called sorting of cocoons. Defective cocoons affect the reeling performance and quality of the silk. Therefore, unsuitable cocoons are to be sorted out from the good cocoons to get optimum result during reeling. The cocoons are sorted into: a) Good b) Double c) Uzi pierced d) Flimsy or thin shelled e) Melted or stained and f) Thin-end cocoons. Sorting will improve the product image and marketability. Reelers always prefer uniform shape in a lot. Uniform shape improves reeling performance and silk quality. Sorted out defective cocoons can be sold in different rates.

Objective: ASSESSMENT OF COCOONS

Cocoons produced are to be marketed. Following points/ characters are generally considered to assess the cocoons in fixing the price.

1) Cocoon Weight:

Cocoons are being sold on weight basis. It will be seen that the weight of the cocoons gradually decreases due to moisture loss and consumption of the fat till the pupa transform into moth and emerge out. Hence, immediately after harvest, deflossing, sort, and weigh the good cocoons. This will be the weight of green cocoons. Make a label indicating race or combination, date of spinning, green weight, etc. while taking to the market.

2) Assessment of Cocoons for Defective Cocoon Percentage:

If the lot is not sorted properly, you can assess percentage of defective cocoons in a lot. For this, take one kg of cocoon from the lot at random. Sort out defective cocoons like double, flimsy, melted, pierced etc. Count and weigh good and defective cocoons separately. Assess defective cocoon percentage by the following formula:

$$\text{Defective cocoon (\%)} = \frac{\text{Wt. of defective (in 1 kg)}}{\text{Wt. of cocoon taken (1 kg.)}} * 100$$

Observation:

Conclusion:

CALCLATION OF COCOON SHELL (SR) RATIO

$$\text{Shell ratio \%} = \frac{\text{Cocoon without pupa (Wt. in gm)} * 100}{\text{Cocoon with pupa (Wt. in gm)}}$$

Result: The cocoon shell ratio of the given lot is ……%

Preparation of balance sheet

Objective: To learn the process of calculation of cost of production.

Procedure: Collect all the data related to all inputs required, cost of labour, collection of data and market study for Quality cocoon production.

Observation: Calculate the cost of cultivation, Net profit and calculation of B: C ratio.

Sl.no	**Items**	**Quantity**	**Rate (Rs)**	**Amount (Rs)**
1.	Late age rearing house			
2.	Egg card			
3.	Labour			
4.	Equipment for rearing			
5.	Hot Water Bath			
6.	Cocoon harvester			
7.	Transportation			
Total cost incurred (Rs.)				

Yield (Cocoon wt. in Kg)	
Net Profit (Rs.)	
B:C Ratio	

Business idea 4: REELING AND PROCESSING OF SILK

Objective: To acquainted with techniques and procedure silk reeling.

Silk reeling is the process by which a number of cocoon baves are reeled together to produce a single thread. This is achieved by unwinding filaments collectively from a group of cooked cocoons at one end in a warm water bath and winding the resultant thread onto a fast moving reel. Raw silk reeling may be classified by direct reeling method on a standard sized reel, indirect method of reeling on small reels, and the transfer of reeled silk from small reels onto standard sized reels on a re-reeling machine. The last technique is primarily applied in modern silk reeling processes.

Good cocoons are sorted from bad ones like stained cocoons, irregular cocoons, flossy cocoons and thin end cocoons.

Various silk reeling devices

There are many types of silk reeling machines in use. The major structural features of the Sitting Type Reeling Machine, the Multi-ends Reeling Machine and the Automatic Reeling Machine are discussed herein

1. Hand spinning wheel

This primitive spinning apparatus is operated by two hands – one to drive the wheel and the other to feed in cocoons. One end of the reeling thread is wound onto each wheel, while cocoons are boiled in a separate pot.

2. Charka type reeling machine

The Charka type is in use in India. This machine is operated with separate work motions in reel driving and cocoon feeding to reeling ends by two men per machine. Each machine has 3 ends or more to a reel, which is the same size as the large wheel of the Re-reeling machine in order to save the re-reeling process (direct reeling method).

3. Sitting type reeling machine

There are two kinds of sitting type reeling machines, foot operated and motor-driven. The motor-driven reeling machine is not equipped with the stop motion attachment. There are obstacles to the production of good quality raw silk as the raw silk thread is wound too rapidly to maintain good quality control.

Process of Reeling

After boiling (cooking) and brushing, reeling started. Reeling is the extraction of continuous silk thread of desired thickness from the cocoon without any break. Before reeling, light brushing of the cocoon surface is done to find out the tip of the silk filament.

Then the ends are all separated out and gathered together, this is called end picking. Generally, filaments from multiple cocoons are combined together and transferred onto the reeling or spinning machine, which then automatically unravels the cocoons and simultaneously create a single strand of silk from the cocoons.

Throughout the reeling process, the cocoons remain in boiling water. When one cocoon gets exhausted, the second one is immediately substituted to reel a continuous and uniform yarn. So the important steps in reeling are brushing, end picking, casting, binding and traversing.

The individual filament must be inter-wined or twisted and cemented firmly so that the reeled filament does not break during subsequent processing of fabrics. This twisting and cementing is done with the help of a special device, called Croissure, which remains attached with the reeling machine.

Preparation of balance sheet

Objective: To learn the process of calculation of cost of production.

Procedure: Collect all the data related to all inputs required, cost of labour, collection of data and market study for reeling of silk (Calculate year wise)

Observation: Calculate the cost of cultivation, Net profit and calculation of B: C ratio.

Sl.no	Items	Quantity	Rate (Rs)	Amount (Rs)	Year wise
1.	Reeling room				
2.	Reeling/Spinning Machine				
3.	Re-Reeling Machine				
4.	Wrapping and Other Accessories				
5.	Deflossing Machine				

6.	Cocoon harvester				
7.	Miscellaneous				
Total cost incurred (Rs.)					
Yield (Cocoon wt. in Kg)					
Net Profit (Rs.)					
B:C Ratio					

Business Idea 5: SILKWORM BY-PRODUCT

The different products of silkworm are used for the following purposes

1. **Mulberry plant**

Neutraceutical compounds in leaves:

Tea made from mulberry leaves is popular in China, Japan and Korea; it is beneficial for diabetic and hypertensive patients. DNJ, GBBA present in mulberry leaves reduces glucose level and blood pressure.

Antioxidants in mulberry fruits:

Ripe mulberry fruits are used to make jam, jelly, pickle and wine

Fuel and compost making from mulberry:

Mulberry waste wood is a good source of cellulose for paper and chipboard industries.

Mulberry shoots can be used as staking material for climbers of vegetable, ornamental or fruit crops and mushroom cultivation.

2. **Silkworm larvae**

Silkworm litter is a rich source of Vermicompost.

3. **Pupa**

Oil extracted from silk moth pupa has numerous industrial applications. After oil extraction, oil cake can be used as moulding material in bakelite industry. Silkworm pupa can also be used as feed for fowl, fish and pig as it is rich in protein.

A fungus *Cordyceps sinensis* cultured on pupae/moths, by use of recombinants have anti-tumour and anti-ageing properties.

4. Waste Silk

Waste silk which cannot be reeled or spun is used to make silk film or silk powder which is used as feed additive for cosmetic products. Sericin can be used for the preparation of skin care items as it can provide excellent protection against ultraviolet rays.

DETAILS OF BY-PRODUCT

BY-PRODUCT OBTAINED	USED AS