SERICULTURE TRAINING GUIDE

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Contents

Part-I: Sericulture (General sericulture)

1. History of Sericulture

Sericulture industry has a history of over 2000years & we can watch old cloths in museum. However, agricultural history is unknown.

Before100years, world wide agricultural situation was very good in china, Italy and Japan. These were the 3 major producing countries. After world war Ⅱ , Italian sericulture was discontinued.

Recently, Japanese sericulture production amount is decreasing in a very high speed.
At present, the major sericulture producing countries are: -

- No.1 -China,
- No.2 -India,
- No.3 -Brazil consecutively.

In Africa, two type silkworms are being utilized.

1. Mulberry silkworms by Morocco, Algeria, Egypt, Nigeria, Kenya, & Madagascar.
2. Another groups are wild silk moths. Bolocera by Madagascar, Anaphe by Nigeria, Gonometa by South Africa. Wild silk production amount is biggest in Madagascar i.e. around 200 MT. Other countries produce less than 10MT.

The reason why mulberry sericulture development was not succeeded in Africa is: JICA was supporting 3 country's sericulture development in Algeria, Nigeria, &Kenya. Other country did not get development support. From developed countries, only Japan still keeps sericulture and technology. Japan had many experience of supporting silk development in different countries including Colombia, Paraguay, Brazil, Thailand, Lao, Nepal, Philippines, Vietnam, Cambodia, India, Lebanon, and Uzbekistan.

Summary of African silk development

a. Not enough of mulberry field research and practice.
b. Silkworm diseases ware not controlled
c. Lack of government development budget
d. Government officers' miss-decision

Summary of Asian silk development
Almost all the countries have sericultural history. So, farmers are keeping only basic knowledge. Experts are already in research work, &any difficulty will get solutions. Already any Asian country had local market.

2. Types of silkworms and distribution in the world (yarn production amount unit mt/y)
mulberry

a. White cocoon(90,000)→world wide
b. Yellow cocoon (5,000) →world wide

Non-mulberry

Eri silk (castor, cassava)(1,500) →Indian market, some to worldwide
Indian tasar silk(100)→Indian market, some to world wide
Muga silk(50)→Indian market, some to world wide
Chinese tasar silk(3,000)→world wide
Borocera(150)→Madagascar market
Anaphe→small
Japanese green tasar→Japanese market
Atacus atlas→small
Qiricura→small
Gonometa→small

Non mulberry silkworm harvesting
Sericulture
In room eri silk
Out door Chinese tasar, Indian tasar, muga, & Japanese green tasar (in net)
Wild Borocera, Anaphe, Atacus atlas, Quicura, & Gonometa

3. Production of mulberry and non-mulberry silk in the world-comparative production efficiencies.

	Rearing	Original cocoon color	After degumming	Reeling	Ultra violet ray Cut %	Finishing
White mulberry	OK	White	Pure White	OK	80%	Soft
Yellow mulberry	OK	Yellow	Yellow white	OK	80%	Soft
Chinese Tasar	OK	Beige	Yellow white	OK	95%	Little hard
Indian Tasar	OK	Grey	Beige	OK	95%	Little hard
Erisilk	OK	White beige dark orange	Yellow white	NON	95%	Most soft
Muga	OK	Beige	Yellow(gold)	OK	95%	Little hard
Borocera	NON	Grey	Brown	NON	95%	Hard
Anaphe	NON	White	White	NON	95%	Soft
Green tasarr	OK	Green	Light green	OK	95%	Little hard
Atacus atlas	OK	Beige	Brown	NON	95%	Little hard
Quricura	OK	Gold	Light brown	NON	95%	Little hard
Gonometa	NON	Beige	Beige	NON	95%	Little hard

	Area of production	History	Care	Creases	Dyeing
White Mulberry	World wide	Old	Dry cleaning	Get easy	Easy
Yellow Mulberry	South Asia	Old	Home laundry	Get easy	Easy
Chinese tasar	North China	Old	Home laundry	Get easy	Little hard
Indian tasar	East India	Old	Home laundry	Get easy	Hard
Erisilk	East India, South China, Vietnam, Bangladesh	Old	Home laundry	Not easy	Easy
Muga	East India	Old	Home laundry	Get easy	Hard
Borocera	Madagascar	Old			Hard
Anaphe	Nigeria	Old			Hard
Green tasar	Japan	Old	Dry Cleaning	Get easy	Hard
Atacus atlas	Indonesia	1998			Hard
Quricura	Indonesia	1998			Hard
Gonometa	South Africa	1995			Hard

Comparative other textile materials

	Finish	Cool	Warm	Sip sweat	Care	Creases	Price
Silk	Soft	OK	OK	OK	Not easy	Get easy	High
Cotton	Soft	OK	NON	OK	Easy	Get easy	Cheap
Wool	Little hard	NON	OK	NON	Not easy	Not easy	Midium
Lynen	Little hard	OK	NON	OK	Not easy	Get easy	Midium
Plyestel	Little hard	NON	OK	NON	Easy	Non	Most cheap
Nylon	Soft	NON	OK	NON	Easy	Get easy	Cheap
Akriru	Soft	NON	OK	NON	Easy	Non	Cheap

4. Review of silk production in Europe, Asia and various developing countries- prospects

Europe

- Domestic market - UK, Germany, Switzerland,
- Export market- Italy, French

Asia

- Domestic and export market

China, India, Japan, Thailand, Vietnam, Uzbekistan, Korea, Indonesia, Laos, Cambodia, Bangladesh, Pakistan, Turkey, Lebanon, & Nepal

U S A

Africa

- Domestic market - Madagascar, Egypt

South America

- Export market- Brazil, Colombia, Paraguay

5. Sericulture Organization – Administrative set up – Research and Training set up – Seed production – Cocoon production and marketing – Reeling and weaving sector- exports – imports – Tariff protection

JAPAN

Technical support

- Farmers- sericulture cooperative- prefecture Sericulture Experimental station-national sericulture institute

Administrative support

- Sericulture cooperative-prefecture office sericulture dept-ministry of agriculture

Agriculture support

- Egg company-young larvae rearing center-farmers-sericulture cooperative

Trading

-Cooperative-reeling factory

Tariff

- Cocoons, raw silk yarn, fabric tariff was high % until 2003, from 2004 every products are free.

General association

- Japan silk association supported by ministry of agriculture & ministry of industry and trade.

CHINA

- Every operation and supporting by national company (Beijing general silk company).
- Importing silk products need permission and high tariff.

INDIA

-Every operation and supporting by governmental agency (central silk board, ministry of industry)

Thailand

- Importing silk products need permission and high tariff, except importing from ASEAN countries.

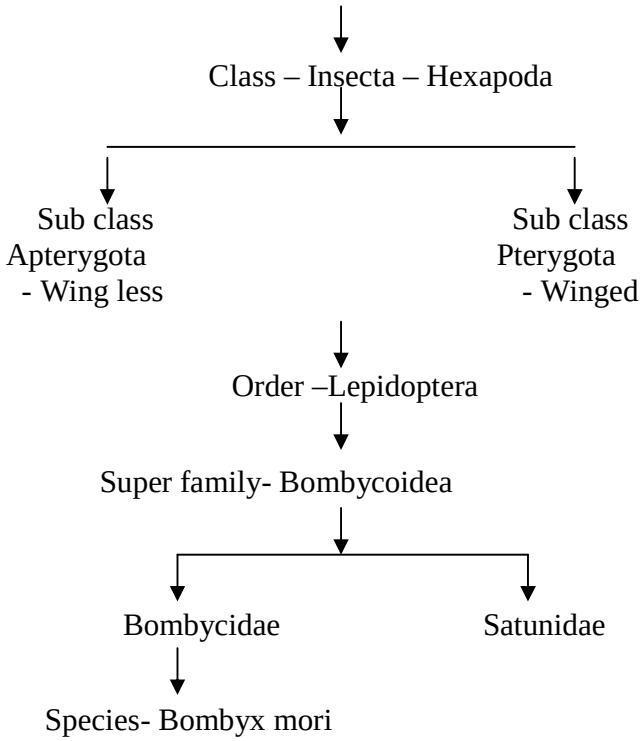
Vietnam –Free

Part-II: Silkworm Rearing Technology

3. Description of silkworms (both mori & eri silkworms)

Taxonomic classification of silkworms

Silkworm belongs to phylum – Arthropods



Bombyx mori-Domesticated mulberry silkworms
Bombyx mandarina- wild ancestor to silkworms

Satunidae

1. Antherea perini – Chinese tasar silkworms
2. Antherea mylitta – Indian tasar silkworms
3. Antherea yamami – Japanese green tasar silkworms
4. Antherea assama – Indian (Muga) worms
5. Philosamia recini – Eri silkworm
6. Eriogyna – Fish line silkworms - was used to make ropes around fishing areas in earlier times

Mulberry silkworm

Mulberry silkworm is biologically named as Bomyx mori, which is obtained originally in China. This is the most widely cultivated silkworm species over the world. The fiber from these silkworm species is ranked as 1st grade as compared to other silkworm species. These silkworm species can be categorized in to three groups based on their generation per year: univoltine, bivoltine, &

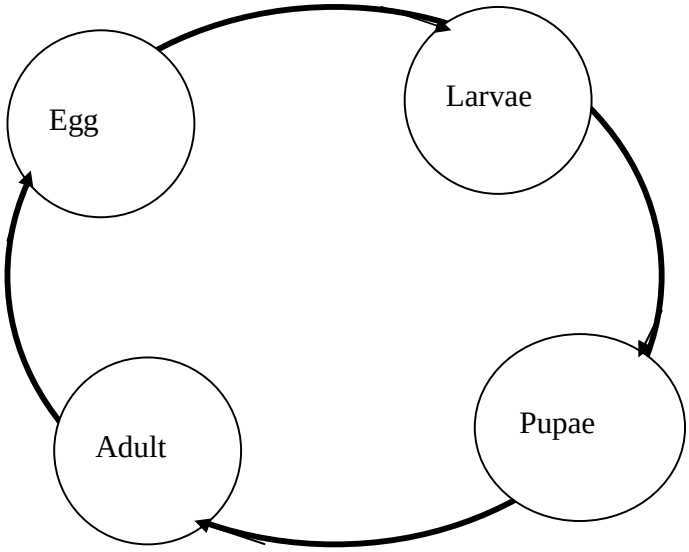
multivoltine. Univoltine & bivoltine groups carry out only one & two generations per year respectively while multivoltine ones carry out many generations (at least 4-5) per year.

Eri silkworm

Eri silkworm is biologically named as Philosamia ricini. It belongs to the family Satuniidae under order Lepidoptera and class Insecta. It is multivoltine breed having five to six cycle in a year. The commonly occurring wild eri silkworm is Philosamia cynthia, which is either bi or trivoltine in nature. Both moths differ slightly in markings and in the amount of white scales in their abdomen. Whereas the cocoon of philosamia ricini is loose and white, that of Philosamia cynthia is compact and light brown. Both hybridize freely.

4. Life cycle of Silkworms (Mori & eri silkworms)

The life cycle of both Mori & Eri silkworms have four stages: egg, larva, pupa encased in cocoon and adult moth. A complete life cycle of eri-silkworm lasts about 44 days in summer and 85 days in winter. Both Mori & Eri silkworm are reared indoors. Rearing of eri can be started when castor leaves are available aplenty.



Note:

- Larval duration for eri takes 26-32 days. It starts at hatching of eggs and goes to the 4th molt stage.
- The duration is generally longer for uni and bivoltine races of mulberry silkworms, but shorter for multivoltine ones & for Eri silkworms, 18-23 days.

3. Rearing houses – basic requirement – orientation - orientation – different designs- modifications to suit changing needs – utilization of locally available materials – vinyl sheds, tile roofed, thatched sheds, mud houses etc…

Planning a rearing house

In order to get a good cocoons yield, it is necessary to plan the entire rearing process beforehand. Quality of mulberry available in a garden is the most essential information required for planning the rearing operation. In tropical countries, a box of silkworm eggs (to produce about 20,000

larvae) requires about 600-800 kg of mulberry leaves. As the whole procedure is labor intensive, the organization of labor and delegation of responsibilities need to be carefully arranged. In India, for instance, at least 40 to 50 labor hours is required to produce 10kg of cocoons. The rearing space required mainly depends on leaf availability; larvae number to be reared at a time, and method of rearing. The method of rearing (shelf rearing, platform rearing, floor rearing) we adopt depends on the space we have for the rearing.

Most Sericulturists in tropical areas use shelf-rearing method, which economizes space. The ideal rearing house is rodent proof and well ventilated. It should also have rooms for rearing chawki worms, for mounting, for rearing grown worms and for storing appliances.

In tropical countries, the rearing house is constructed with an east-west orientation to avoid direct sunlight. The house should be oriented in a north-south direction in temperate regions. Low cost rearing equipment can be manufactured locally from a variety of available materials. Often, production of all ancillary equipment can be developed in to small cottage industries, each with its own employment and sustainable income potential. The basic equipment for shelf rearing should be made available and ready to be installed before rearing begins.

4. Equipments – equipments used in rearing different types and modifications

Equipments for mulberry silkworm rearing

Production efficiency depends on good planning of infrastructure in the grainage. Adequate equipment, preferably made locally, should be available. Different items are required in different quantities, depending on DFL production capacity (Table 1).

Table 1. Grainage equipment for 5000 DFL production capacity

Item	Quantity
Tray racks	20
Wooden tray stands	8
Wooden stools or benches	10
Refrigerator	2
Ventilator	1
Incubator	1
Acid treatment bath	1
Humidifiers	4
Room heater	4
Moth-crushing equipment	10
Hydrometers	2
Hygrometers	4
Thermometers	2
Egg cabinet	1
Seed cocoon bins	20
Cellules	3000
Sprayers	1
Gas masks	2
Washing trays	2
Tinner	1

Buckets, bowels, mugs, and overalls are also needed

Appliances needed for eri silkworm rearing

In case of branch feeding, only two bamboo stands, a horizontal rod, a mat (spread over the floor of the rearing house in order to collect the eri worms when they fall from the bunch) and leaves are required for spinning. In case of tray rearing, the rearing house should be fitted with bamboo shelves, small and medium size bamboo trays, spinning trays, bamboo mat, a maximum and minimum thermometer, a dry wet bulb hygrometer, knife, a small wooden plat form, basket, thick gunny cloth, bucket, disinfectants such as formalin, copper sulphate, bleaching powder, lime, glass cylinder, glass beaker, funnel, scissors, measuring cylinder, old newspaper, rearing register, max-min thermometer, humidity and rainfall register, cocoon quality test register, microscopically examination register (microscope 750 x with oil emersion), leaf register, glass slides, cover glass, pestles and mortar 3' diameter, rain gauge with full equipment, country balance, chemical balance, magnifying glass, sprayer, aluminum pot, absolute alcohol, silk handkerchief, fine cloth khorika, wire/net covered wooden box or cage, small basket, table, thread ball, glass jar, forceps, scalpel, etc.

Generally, appliances for mulberry silkworm rearing may be used for eri silkworm rearing except the thread nets. For spinning cocoons, the cheapest materials are dry plantain leaves, mango twigs with dried leaves, and bamboo twigs. In some hilly areas, a kind of bamboo is used for mountage. The bamboo about 6' long is split in the middle. Ripe worms are placed in the split bamboo and tied together by means of a rope or creeper. Cocoons mounted in this way are uniform and clean. Leaf register is also maintained to note the consumption of leaf during the entire larval period of the brood. Rearing registers are very important to study the yield and quality of cocoon.

If there is any block plantation of castor, a cultivation register should be maintained to get an idea about the leaf yield, seed yield and cost of maintenance of the castor field. So, one cannot ignore the importance of the eri industry.

Freshly laid eri eggs are whitish as the embryo develops inside the eggs, the color of the shell changes from whitish to yellowish, then ashy and to blackish just before hatching. Then a tiny worm comes out leaving the shell all white and empty. Eggs usually hatch in the morning between 7 and 10AM

To get uniform hatching, they should be incubated at a temperature of 22.2^0c-26.7^0c. The minimum number of days from oviposition to hatching is about 8 but the maximum may be 20days or more. This difference is due to differences in environmental temperature. With the help of a refrigerator or cold storage, the hatching can be retarded just as it can be accelerated and regulated in an incubator. Eggs laid by the female moths on the stick or kharikas or cloths or in a small split bamboo basket are scraped off, tied in a piece of cloth, and hung up under the roof until they hatch. When warm wind blows, the eggs shrivel up but do not hatch. To avoid this, eggs should be stored in a cool place covered with a piece of thin moist cloth. When the tiny worms hatch out of the eggs, they should be carried over to a tray and covered with another tray over which a wet sheet is spread and kept constantly moist

5. Preparation for rearing – cleaning and disinfection – types of disinfectants, their use, effective disinfection and hygienic conditions

A silkworm rearer aims for a good yield of best quality cocoons, which have the best market value. All techniques and practices are aimed at obtaining this result with minimum labor and expense.

Leaf quality, environmental conditions, and general hygienic conditions influence the health of the worms. It is important to rear young silkworms in a very clean environment and to feed them with adequate quantities of fresh, tender, and nutritious leaves. Therefore, we have to consider all these during our preparation for silkworm rearing.

Disinfection of seed

Like eggs of mulberry silkworms, eggs of eri silkworm are also disinfected with 2% formalin and washed in cold tap water to remove traces of formaldehyde, and they are dried under shade. There are different types of disinfectants including formalin, copper sulphate, bleaching powder, & lime.

6. Environmental conditions required for rearing – simple methods to control temperature and humidity to suit the different stages

Increased humidity in the rearing bed keeps leaves fresh for long periods. The ideal condition for healthy growth of chawki silkworms is to maintain a temperature of 26-28 ^{0}c with 90 % humidity. After the third instar, the temperature is reduced to a minimum of 25 ^{0}c and the humidity to 75 %. Young worms are susceptible to high concentrations of carbon dioxide and, as the rearing of chawki worms is often conducted in closed, warm and wet conditions to prevent mulberry withering, it is necessary to let fresh air in at least three times a day to prevent the build up of this gas. The growth rate of a worm is at its highest during chawki rearing stages. Although feeding is important, over-feeding causes piling up of uneaten and leftover leaves, which is bad for health of the worms.

7. Incubation – hatching – different methods of brushing – young age silkworm rearing – methods of rearing – feeding young age worms – moulting – cleaning and spacing – organization and cooperative chawki centers – Advantages

Incubation is an important step for rearing. Incubation also: seed warming" by which the developing silkworm eggs (embryos) are provided with proper environmental condition so that the embryos can develop normally and the eggs hatch uniformly. Consequently, viable cocoon crops (yield) can be attained. Wherever facilities are available eggs are to be incubated in the grainages upon the head pigmentation stage and then supplied to the farmers in a black box specially designed for it.

7.1 Transportation of eggs

The eggs are transported preferably in cool hours to prevent desiccation during hotter periods of the day. Boxes made up of wood or thermo Cole with adequate ventilation are preferred. Pacing a wet blotting paper or sponge strip inside the box helps in increasing the humidity. CSRTI, my sore has developed an egg carrying box (Fig .3) which is found suitable for carrying eggs for long distance (more than 100km). To obtain good and uniform hatching of silkworm eggs, a simple egg caring box has been designed providing optimum environmental condition for proper embryonic development. The egg sheets are hung inside the box loosely. The bag protects the eggs from direct sunlight and shock during transportation. Water need to be sprayed over the bags at 10ml/100cm^2 . Water spraying increases humidity inside the box which helps in reducing the desiccation of eggs. In case of longer distance, it is advisable to spray water periodically.

7.2 Incubation chamber/room

An incubation room is used when large number of eggs are to be incubated, wherein uniform temperature and humidity are maintained. It must also have heating and cooling devices, sufficient illumination and proper ventilation (Fig.4).

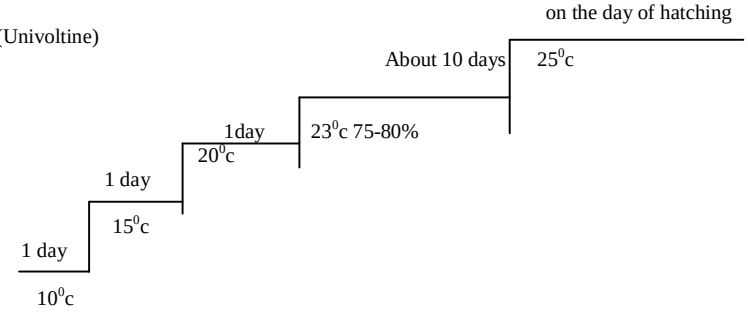
7.3 Temperature and humidity

Hibernated eggs of pure race (bivoltine) for incubation need to be released through increasing temperature gradually i.e 10^0c,15^0c 20^0c for about 24 hours in each temperature where as for hybrid eggs, an intermediate of 15^0c for one day is required. Then they have to be socked in 2% formalin for 5 minutes, washed in water and dried. The eggs are then shifted into incubation chamber and put in order by labeling i.e. race, source, batch number and date of collection.

The egg cards should be spread in single layer in the trays. In the cases of loose eggs, they must be spread out thinly in incubation or brushing frames. To obtain maximum hatching, optimum incubation temperature is 23^0c unto 11 days and 1 day at 25^0c (blue egg stage) for univoltine and 25^0c upon 10 days 1 day at 26.5^0c (blue egg stage) for bivoltine (hibernated or acid treated and cold stored). The standard method of incubation of eggs is given on next page:

7.4 Standard method of incubation of eggs

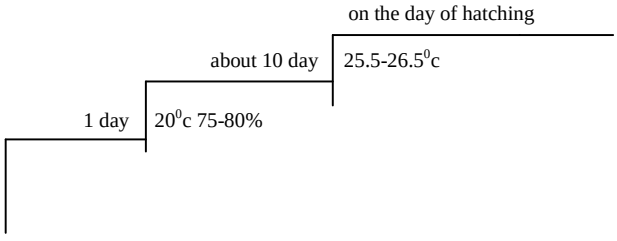
1. Hibernated eggs (Univoltine)



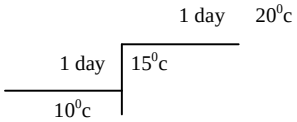
Take out from cold storage

2. Hibernated eggs (Bivoltine) or

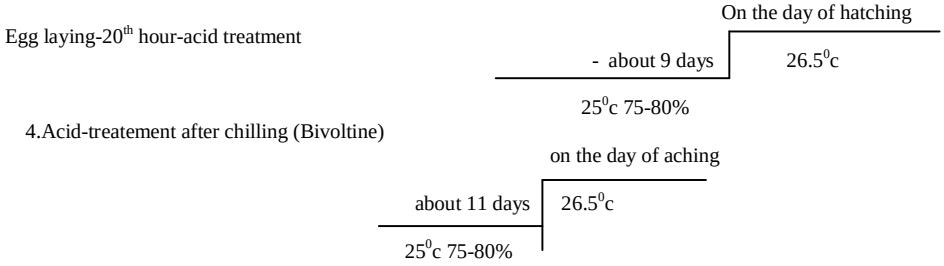
Acid treated and clod stored



Take out from clod storge.



3. Common acid treated eggs (Bivoltine) followed by incubation(without cold storage)



4.Acid-treatement after chilling (Bivoltine)

Take out cold storage 5-6 hours before acid treatment
Note: provide 16 hours during incubation.

7.6 . Air

Incubation room or chamber must be opened/ventilated daily for 10 minutes in the morning and evening during incubation.

7.6. Light

The light also affects uniform hatching and voltinism during incubation period. From the very beginning. Of incubation upon the eye spot stage, light hastens the embryonic development. However, during final hatching stage, darkness inhibits development. Light more than 16 hours a day induces the hibernating character in silkworms. The uniformity in hatching is obtained with regulated control of light. Light should be provided for 16 hours a day, till head pigmentation stage. At blue egg stage, the eggs should be kept in darkness by covering with black paper or cloth to obtain uniform hatching.

7.9. Exposure of silkworm eggs to light

When stray hatching is noticed on the egg card (a few larvae hatch out), the eggs are exposed to light. This ensures uniform hatching and within two hours all the larvae will hatch. The hatching date can be determined by the embryo development with reference to the color of the egg and distil niceness of the egg dimple. In case of loose eggs, the are spread in the box or incubation box or brushing frame (specially meant for it) in a thin layer by shaking gently. Cutting the egg box cover cloth through the sides without damaging the eggs and keeping the same turned up with the egg sticking to ia at the time of exposure to light can be done (if brushing frame is not used).

7.10. Cold storage of “blue eggs” new born larvae

Hatching of eggs during incubation can be delayed by clod storing the eggs at blue egg stage at 5^0c for seven days, but a shorter time (3-5 days) is preferable whereas, newly hatched larvae can

be clod stored for 3 days at 7-10^{0}c. The humidity in the cold storage room should not be less than 75 to80%. Wrapping the egg or larvae. Container with wet cotton cloth or blotting paper helps in increasing the humidity.

7.11. Rotten eggs before head pigmentation

Sometimes rotten eggs, such as brown rot, red and grey rot eggs are noticed during incubation. Several factors cause this type of damage.

-Exposure to high temperature (above 28^{0}c) and high humidity (above 90%) during egg laying and incubation.

- Storage of hibernating eggs at 25^{0}c for too long a period (more than 90 days) under dry and high temperature conditions.
- Over stimulation of eggs during acid treatment.
- Contact of eggs by pesticides, nicotine, mosquito repellant, incense, oil or sticky material such as glue or gum.

7.12. Dead eggs after head pigmentation

Two types of embryo death can be noticed, viz, at head pigmentation stage and when eggs turning bluish (one day before hatching). In both the cases, the embryo is normally formed in the eggs shell but death occurs before hatching stage. The factors for this are:

- Too high temperature during incubation (above28^{0}c).
- Too low relative humidity during incubation (less than 50%). This condition not only causes the death of the embryo but may also result in un-uniformity in hatching and under weight of newly hatched larvae.
- Contact of eggs with pesticides, nicotine or other toxic materials.

7.13. Brushing

Expose the eggs to light at 6:00 a.m. and brush the hatched larvae at 10.00 a.m. to avoid starvation of newly hatched larvae. In a tray of 1.2m x0.9m size 25 dfls (bivoltni) can be brushed and reared till the end of second stage. Which brushing loose eggs, spread a net of mesh size of 2 mm and give feeding. Sprinkle the chopped tender lease of 0.5 to 1 cm size over the hatched larvae.

Chawki rearing Center/ CRC/

It is an establishment where young healthy silkworms are reared. To harvest bumper cocoon yield, it is advisable to apply scientific method of young age silkworm rearing which is an important part of the new technology of silkworm management. This can be achieved only by feeding chawki worms with highly nutritious leaves in adequate quantities of suitable intervals. The main constraint was the non-availability of exclusively chawki garden, which would economically yield quality tender mulberry leaves (with about 80% of moisture). It is now realized that for reaping the benefit of chawki rearing center, a mulberry full plot exclusively maintained for production of quantity succulent leaves, should be attached to the center.

The plots taken for the purpose could be manured with FYM which could be 20 tons/ha/y, and also could be applied with chemical fertilizers (N at the rate of 200 kg/ha/y. The chemical fertilizer (N) were supplied about 10 days after pruning and irrigated once in 10 days. Harvesting of leaf for young age worms could be started 45 days after pruning crop utilization period extends to 9-10 days. After harvesting of the left over leaves (those not utilized for chawki rearing), the plot was pruned. The duration from one pruning to another pruning could be 60 days. The quantity of leaves required for rearing 50 dfls or a box of 20,000 eggs required for the first three instars is given below.

Age	Quantity required (kg)
1st age	1-2 kg (Succulent leaves)
2nd age	2-3 kg
3rd age	15-20 kg
Total	**18-25 kg of mulberry**

To rear Eri silkworms, the same amount of leaf is required to rear 20,000 worms.
The recommended chawki rearing house could be designed in such a way that it can accommodate sufficient silkworm rearing facilities depends upon the capacity of the laboratory set up.

It is advisable to have a building size of 5m x 10m or 5m x 3m or 4m x 3m with 3 windows and a door. The laboratory could be constructed from any local material and be white washed on any recommended wall paint. The room could have enough ventilation system and a varanda all around.

Item	Quantity
1. Racks (2.25m x 0.75m x 2.50m)	2 x 2 = 4
2. Tray (90 cm x 60 cm x 6 cm)	60 x 2 = 120
3. Bench (1.80m x 70cm x 30cm)	2 x 2=4
4. Paraffin /wax paper/ cleaning item	10
5. Bucket	2 x 2 = 4
6. Washing basin	8
7. Thermometer	2
8. Sprayer	2
9. Feeding net	40
10. Formalin/Soap	5 litres
11. Gunny cloth (Sacks)	50
12. Egg card	50
13. Cocoon cabinet	10
14. Room heater	4
15. Glass mask	1
16. Cheese cloth	5 meters

17. Broom	4
18. Charcoal	4 bags

8. Rearing late age silkworms – environment – rearing methods – leaf preservation – spacing

Rearing fourth and fifth in star silkworms

The fourth and fifth instar silkworm larvae differ from earlier stage silkworms in many respects. They are susceptible to high temperature, high humidity, and poor ventilation but can tolerate poor quality mulberry leaf to a certain extent. Good ventilation is necessary to displace the bad air breathed out by thousands of fast-growing worms in the rearing room. Conversion of leaf protein into silk within the silk glands occurs in these instars. So, the leaf fed to the silkworms should have high protein content. The grown worms are voracious eaters consuming 75 to 80 percent of the total leaf required for their growth. A large quantity of leaf is consumed by silkworms during the fourth and fifth instars (table 4) and correspondingly a large quantity of leaves must be harvested daily, which requires more labor. In order to reduce labor costs and to preserve the leaf quality for long period, many farmers prefer shoot rearing. It is done indoor either on the floor or on the platforms that may be on two or three tiers. Whole shoots are placed on the platforms which form the rearing bed for grown worms. This practice reduces the labor required for leaf picking and leaf preparation for feeding.

Table: - Climate, leaf, and space requirements for grown silkworms

Requirements	4^{th}	5^{th} instar
Type of leaf	Medium	Medium coarse
Leaf size	Whole or shoots	Whole or shoots
Temperature	$25^{o}c$	$24^{0}c$
Humidity	75%	70%
Space (1box eggs)	3 to $9m^2$	9 to $18m^2$
Quantity of leaf	50to 60kg	370 to 420kg

Ensure the availability or required quantity of rearing appliances, quality and quantity of leaf to complete the late age rearing. The minimum requirement of late age rearing equipment for 100 dfls (40,000) larvae) is given in table 4.

Table 4. Requirement of rearing equipment/100 dfls (40,000 larvae) for late age

Sl. No. Item	Quantity
1. Round bamboo trays (1.2m dia or) Wooden trays(0.75m x1.05m)	40
2. Rearing stands (10 trays/stand)	4-5
3. Ant wells	20
4. Cleaning nets	100
5. Feeding Stands	3
6. Bamboo spiral mountages (1.8m x1.2m)	40

or plastic collapsible mountages (19 foils)	100
7. Room Heater (Thermostatic control	1
8. Gator Sprayer	1

9. Mounting and spinning – methods of mounting – different types of mountages – mountages from locally available materials – harvesting and cleaning of cocoons

Cocooning

Silk worms molt four times during their developmental period. After the fourth molt, worms begin to eat voraciously for a few days. All the internal and external organs of the worms reach the maximum stage of development during the last larval period. Then, they loss their appetite and become restless to spin cocoon. They move about in search of a suitable place and settle down to exude secretion from the silk gland through the spinneret which, coming in contact with the air of the room, forms a fine filament of thread.

Before spinning, all the ripe larvae completely give out entire intestinal mass of excreta (liquid and solid) as a prelude to set out building of cocoons shells. Matured, ripened worms produce hollow sound when it is rubbed between fingers.

Mounting of matured larvae for spinning

- The mounting and cocoon harvest operations are the final steps in silkworm rearing. If these operations are not handle properly, the quality of the silk may be adversely affected and 25 days hard work carried out earlier will be a waste.
- Reduce the feeding quantity and leaf size when spinning commences, but the frequency of feeding may be increased in the penultimate day.
- Arrange the required number of mountages well in advance and also mount the worms when they are fully mature. Any negligence at this stage is bound to cost the rearer heavily.

Mountages

Mature worms ripen mostly in the morning usually between 9:00 a.m and noon. This is therefore, the most appropriate time for rearers to pick and place such worms in spinning baskets or mountages similar to chandrikes used for mulberry silkworm. Bamboo baskets used for spinning cocoons should be filled with dry leaves of mango and banana, and in between folds of leaves, mature worms are placed and the leaves are tied together by a rope or creeper. Cocoons to be mounted in this way should be uniform in size and clean. Proper ventilation is needed when eri worms spin cocoons.

10. Assessment of quality of cocoons – maintenance of records – cost of production etc.

Cocoon assessment

Next day after harvesting, deflossing of cocoons is to be carried out (Fig.15). Then sorting of cocoons (i.e melted, thin shelled, Uzi infested, deformed and double cocoons) is to be done (Fig.12). These defective cocoons are to be records systematically in the date sheet. After sorting,

by gently shaking each cocoon for live papal sound, cocoon number (pupation rate) is to be calculated. The number of dead pupae cocoons is also to be recorded. Count the live cocoons by using counter specially meant for it. Then act ual of counted cocoons weight of counted cocoons should be recorded.

Divide the batches (each bed) into two equal halves. From one, take 50 cocoons from cellular batch and 50 to 100 cocoons from hybrid batch at random. The use of cocoon counter is recommended. The cocoon assessment is done by using electronic balance (Fig.13). Cut the cocoon shell weight and cocoon shell ration of both male and female separately (Fig.13a & 13b).

After the completion of total procedure, from the remaining half, 50 reliability cocoons in the case of cellular batches and 300-1000 cocoons in case of hybrids should be selected at random and weight. Theses cocoons should be sent for reeling test.

11. Rearing management to suit different seasons - modification for semi-arid and humid tropics.

Application of silkworm rearing condition: -

- ❖ Humidity condition
- ❖ Ventilation system
- ❖ Effective sanitation measures
- ❖ Silkworm population handling &number of feeding to suit different instars

12. Review of rearing technologies.

- Follow the general improved silkworm rearing technique

Practical - *4 units*

1. Morphology - silkworm egg, larvae, pupa and moth
2. Mulberry and non-mulberry silkworms comparative study at egg, larvae, pupa and moth stages.
3. Anatomy – digestive system – silk glands – tracheal system – nervous system – reproductive system – excretory system
4. Whole mounts – larval mouthparts – spinneret – gonad – spiracle- ocellii
5. Model rearing house-plan
6. Rearing equipments- shelf-trays- wooden boxes-bamboo trays, chopsticks, chopping knives - chopping board- feeding stand- foam pads- basin stand- feather- paraffin paper- hygrometer etc.
7. Disinfection of the rearing rooms and appliances- spraying and fumigation- materials required.
8. Brushing- methods of brushing- rearing young age worms- cleaning- feeding and spacing schedules for chawki silkworm rearing.
9. Leaf preservation for silkworm rearing.
10. Rearing late instar- cleaning, feeding and spacing- humidity, temperature requirements - schedules for rearing late age silkworms.
12. Mounting- different types of mountages- methods of mounting.
13. Harvesting and cocoon assessment.
14. Maintenance of records for rearing silkworms.

Part III: Seed technology, pathology & entomology of silkworms

C. Seed technology

3. Grainage and seed production

- Model grainage- equipments for grainage- selection of seed cocoons - preservation of seed cocoons-sex separation of pupae for hybrid preparation - maintenance of temperature and humidity
- Moth emergence- planned program of hybridization- methodologies to identify male and female moths- coupling- duration of coupling and its importance on fertility- refrigeration of male moths – temperature and humidity for preservation- egg laying- moth examination in boxes - preparation of loose and sheet eggs- transportation.
- Importance of individual moth examination - identification of Pebrine -identification of flacherie and poor layings - sampling of moth examination.

Grainage planning for production

Sericulture involves activities such as mulberry cultivation, silkworm rearing, egg production, cocoon production, raw silk reeling, spinning, throwing and weaving.

Setting up grainages

Grainages are establishments or centers where silkworm eggs or seeds are produced. Success of the industry depend on the quality of egg or seed it avails to farmers. In a new sericulture area where silkworm eggs are not available locally, farmers depend on an outside source. Although procurement from outside is inevitable, it poses problems in the long term. To establish silk production, we need to have a reliable supply of hybrid silkworm eggs and a market demand for reeled silk.

The infrastructure for sustainable and good quality silk production can be achieved by ensuring good facilities for silkworm egg production (grainage) and centralized silk-reeling units. For the sustainability of the industry, self-sufficiency in hybrid seed production is essential. The primary objective of a grainage is to produce disease-free eggs. This is achieved by producing eggs from healthy and robust parents. Before building a grainage, one has to assess the need for its establishment. Mulberry cultivated on a minimum area of 500 acres of land can support a small viable grainage unit producing 50,000 disease free layings (DFLs) a month.

Location

Sericulture should be based basically at a place where large number of farmers practice silkworm rearing so that the demand for seed exists, preferably through out the year. The climate should also be conducive to egg production. Temperature of 24-26 ^{0}c and humidity of 75-80% are ideal but are not available all the year anywhere. However, production can be effectively achieved if the ambient temperature in a region neither exceeds 32 ^{0}c nor falls below 20 ^{0}c at any time of the year. The parent cocoon producing area should be near to ensure easier transport of the seed cocoon.

Building

The building should be spacious and cool and should have separate rooms for cocoon storage, moth coupling, egg laying and acid treatment. In warm regions, a two-store building is preferred. Since the ground floor is cool, it can be used for cocoon storing and ovipositor (egg laying). The major part of the building will be utilized for cocoon production, but a room of 25m^2 floor area, in which 5,000 bivoltine or 10,000 multivoltine cocoons can be stored, is required.

The building should have well ventilated and conveniently sized rooms for easy regulation of temperature and humidity. As moths are sensitive to light, the building needs to have facilities to regulate light. It is very important to maintain temperatures cool in the room when couplings and oviposition take place. An open space adjoining the building is necessary to prevent moth-scale dust from affecting workers. There should be a good, continuous water supply to the building. There should be an open yard for disinfecting the appliances and sun-drying the pierced cocoons (empty cocoon shells after the moths have emerged). A separate, well-ventilated, rodent-proof room or a shed situated away from the grainage should be made available for storing pierced cocoons.

Staff

Effective management of the grainage by well-trained staff determines the quality of egg production. It is necessary for staff to have sufficient knowledge and skill in processing and handling of eggs. They should forecast seasonal demands and plan egg production accordingly.

4. Seed Organization

Seed areas and their importance- supply of basic seed- p4, p3, p2, p1- organization of seed supply to the seed areas- care and precaution to be taken in seed areas- extension and its importance- marketing of seed cocoons .

MULTILOCATION OF SILKWORM BREEDS AT P4 AND P3 LEVEL

"Seed organization" comprises the maintenance of breeders stock and its multiplication for the ultimate production of large quantity of commercial hybrid seed. Therefore, the maintenance of breed characteristics (purity, vigour etc.) is of utmost importance. The breeds stock maintenance should be the responsibility of breeders of Research Institutes, which in turn (now and then) should supply the basic seed for further multiplication. The breeders stocks will be multiplied 3-4 times in a year (favorable months) and the different multiplication level are

designated as P3, P2 and P1. However, a three tier system is considered more ideal and efficient which is followed in all sericulturally advanced countries. The breeders stock and multiplication centers should be under the control of Government agencies and well trained persons.

❖ Procedure for multiplication of basic stocks at P4 and P3

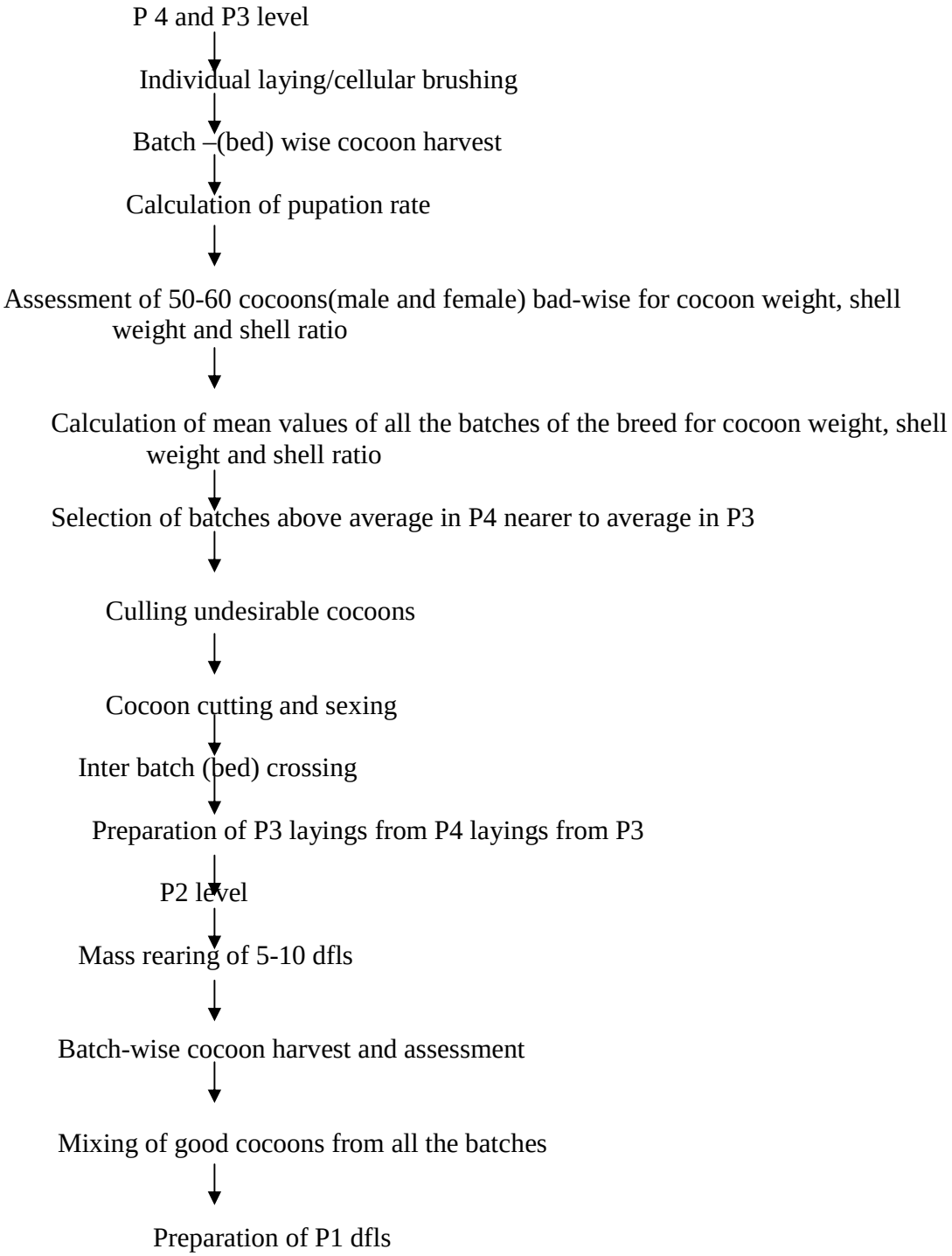
- Plan and programmed the basic seed production based on the requirement of eggs for next level of multiplication. There should be an integrated programmed to supply the eggs to various multiplication center.
- Prepare a flow chart and supply programme for one year in advance for effective monitoring of the production and supply of basic seed.
- Brush 10-30 dfls of each breed in cellular batches (individual laying) depending upon the demand and supply of laying.
- Count all the larvae after tired molt and retain till spinning .
- Sort out dead pupae-cocoons, malformed cocoons, stained cocoons, thin shelled cocoons etc., after the cocoon harvest. Live pupae cocoons only are taken for calculation.
- Calculate pupation rate on the basic of live pupae. Live pupa can be known by the sound when the cocoon is gently shacked. Extreme low pupation percentage batches are to be rejected (e.g. 10% below the average).
- Calculate the pupation rate for the number of larvae and muscardine affected if any, from the original number and calculate the pupation rate only for the remaining basic number of larvae.
- Take 50-60 cocoons at random in each batch and sex them. After sex separation, record mass cocoon weight, shell weight and cocoon shell ratio separately for both male and female cocoons. Take the mean of both the sexes in each batch.
- Calculated the mean of cocoon weight, shell weight and shell ratio of all batches of the breed.
- Select only the batches above average for pupation (in each breed).
- Eliminate the batches which have produced cocoons with undesirable shapes, thin shell cocoons and poor growth performance.
- In case of P4, select the batches scoring above the average for all the three traits viz., cocoon weight, shell weight and shell ratio (minimum 3 batches are to be selected)
- In case of P4, select individual cocoons. This should be done as per the guidance of the breeder.
- Whereas in P3, select the batches above average or nearer to average for the three traits like in P4 (minimum 3 batches are to be selected.
- Do not resort to cocoon selection for P3 batches. Select only the batches based on their merit.
- For every rearing the P3 layings should be obtained from P4 stock.
- The selected batches of each breed both in P4 and P3 are to be interbred/inter-batch crossing for rising next generation (e.g. 1x3,2x3,3x1)
- Depending on the required number of dfls, keep equal number of male and female pupae for egg production (e.g. to prepare 100 dfls 300 female and 300 male pupae are to be kept). If there is shortages (less) of males, use the same males two times for egg production.

- After egg laying, all the mother moths should be subject for pebrine test individually.
- Make provision to preserve (P4 and P3) eggs under different hibernation schedules.
- Replace the breeders stock from breeders stock from breeders once or twice in year.

❖ Multiplication of silkworm breeds at P2 stage

- -For every rearing, the P2 layings should be obtained from P3 stock
- Depending upon the require of P1 dfls, the P2 dfls rearing should be prepared. To produce 1000 P1 defls , 6000 pupae are required i.e ., 3000 males and 3000 females. The approximate survival rate is 50% of the total larvae brushed i.e, 12,000 larvae.
- 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-cocoon are only taken for calculation of pupation rate.
- Adopt mass cocoon assessment of 50 males and 50 female in each batch to record cocoon weight, shell weight and shell percentage.
- Record date systematically.
- Cull out undesirable cocoons. Do not resort to any cocoon selection
- Utilise all good cocoons for P1 laying production.
- After egg laying, all the mother moths should be subjected for pebrine test individually
- Create data base systematically in Basic Seed Farms (BSF).

❖ **Flow chart for multiplication of P4, P3 and P2**.



MAINTENANCE OF SILKWORM STOCKS (GERMPLASM)

Collection, characterization, conservation, evaluation and systematic maintenance of silkworm stocks without loosing their original qualitative and quantitative traits are of utmost importance.

D. Silkworm pathology

1. Pebrine (protozoan disease) – causal agent- mode of infection- symptoms- prevention and control.
2. Bacterial diseases of digestive organs- septisemia- sotto disease- rangi disease (court)- causal agents- infection- symptoms- prevention and control.
3. Fungal disease- muscardine- aspergillus disease- causal agents- symptoms- prevention and control- cleaning and disinfection of rearing rooms and appliances.

Silkworm diseases and preventive measures

Silkworm suffers mainly from types of diseases viz.

1) Pebrine
2) Muscardine
3) Bacterial and Vrial Flacherie.
4) Grassrerie and Uzi fly pest infestation.

- Adopt strictly and effectively, the recommended disinfection practices and hygienic measures to prevent.
- Prevent contamination of rearing house and silkworm beds totally during rearing.
- Clean the floor with bleaching powder solution (5%) after day feeding during V age.
- Subject the suspected diseased larvae for microscopic examination to take suitable.
- Avoid high temperature and high humidity conditions particularly during late age rearing.
- Apply bed disinfectant (Resham keet oushad) after every molt, before resuming the bed and 4^{th} day of V instar after thorough bed cleaning as well as on the matured larvae before mounting.
- Make the rearing house fly proof by using nylon net or wire mesh to prevent uzi infestation.
- Use uzi trap tablets to control uzi fly. The solution prepared by dissolving one uzi trap table in 1 liter of water can be effectively used to kill both the sexes of adult uzi fly. The basin containing uzi trap solution should be placed outside the rearing house at the height of window-base to trap the files.
- Destroy the uzi infested larvae and pupae immediately by burning.
- Seal the crevices in the rearing house and the appliances to prevent pupation of uzi maggots and their emergence by effective disinfection.

Bed refuses particularly diseased crop should not be used directly for mulberry garden. Bed refuse and other wastes should be thoroughly decomposed for a minimum.

Moth examination

For selecting the best eggs, moth, examination is conducted according to Pasteur system. Soon after egg-laying, all female moths are examined for pebrine spores. In preparing industrial laying, 100% moth examination is impossible therefore, only sample test is carried out. That is moths are put in a mortar with a 2% caustic potash solution and ground with pestle. Later, the crushed juice is spread over a glass slide converted with a slip and examined with microscope. If pebrine spores are detected, the eggs of these moths or batch of moths are rejected forthwith.

C. *Entomology*

1. Insect pests of silkworms- Indian uzifly pest- Tricholyga bombycis- Japanese uzifly - stored cocoon pest detested beetles- nature and extent of damage- control measures.

Practical

A. Seed Technology

1. Selection of seed cocoons.
2. Storage, handling and protection of seed cocoons- temperature and humidity requirements during storage
3. Identification of male and female pupae.
4. Moth emergence, time of emergence, identification of male and female moths - handling, and protection.
5. Pairing- depairing- preparation of laying/loose eggs- pure line and hybrids - hibernating and non- hibernating eggs.
6. Moth examination- purpose and observations
7. Incubation of layings.

B. Silkworm Pathology & entomology

1. Pathogens causing Pebrine and Flacherie in silkworms
2. Collection and identification of insect pests.

Part IV: Biology, breeding & agronomy of mulberry

1. General- historical origin, distribution- climatic conditions required.
2. Uses of mulberry
3. Classification of mulberry
4. Characteristics for mulberry cultivation (soil, rainfall, humidity, etc)
5. Methods of propagation sexual and asexual means seed collection- viability- storage- germination and transplanting

6. Quality of mulberry leaf
7. Pathology & entomology of mulberry- Diseases and pests of mulberry
8. Preparatory cultivation of mulberry- establishment of nursery- planting systems- suitable for different agro- climatic conditions .
9. Irrigation- purpose- soil moisture concept- methods and frequency of irrigation.
10. Cultural operations- intercultural operations- weeds.
11. Role of plant nutrients- manures and fertilizers- types and composition- properties of different manures and fertilizers- preparation of compost- quantity of manures and fertilizers - method of application.
12. Pruning- different systems and frequency of pruning.
13. Package of practices for maximizing the leaf yield of mulberry for different agro- climatic conditions.
14. Estimation of leaf yield from a plot- selection and harvesting of leaves for rearing of larvae of different stages- different harvesting methods- transport and preservation of leaves.

Food plants of Mulberry
Silk worms

Mulberry (Morus in Latin) is the main feed plant of Bombyx mori L. It is a diploid with 28 chromosomes and grows as a bush in tropical countries. There are over 200 species of mulberry varieties. Today mulberry is universally distributed between 23^0 south and 45^0 north of the equator. Thus it is produced in China, Korea, Japan, India, Russia, France, Latin, America and Africa.

Mulberry is the basic food for silkworm, and the bulk of silk goods in the world is produced from mulberry silkworms. Therefore, producing mulberry leaves on scientific basis is essential for organizing sericulture on sound economic lines. Under intensive cultivation practices in tropical countries, leaves of about 30 tons per hectare can be harvested per year.

Studies of 200 varieties on ecological aspects and adaptability, which have been included under breeding programs, have helped in selecting varieties suitable to different agro-climatic tracts; and studies on horticultural aspects of the plant have helped in adapting various training, pruning and other plant regulatory practices to make the plants grow as bushes, middling or trees for leaf production. It has been found that irrigation, fertilization and proper cultural practices such as weeding, inter-cultivation, and mulching influence mulberry production. As there are some pests and diseases of mulberry leaves, insecticides and fungicides that are harmless to silk worms could be used.

General aspects of mulberry

Rainfall and temperature

Mulberry grows in areas with 635 mm to 2500mm rainfall. Under low rainfall, its growth is retarded and supplemental irrigation is therefore needed. Atmospheric temperature of mulberry growing areas should be 13^0c -38^0c; the optimum temperature is 24^0c -28^0c.

Agronomy

Mulberry farm should be established near the rearing house and it is better if it is uniform upland bund. The plant prefers loamy, alluvial, volcanic and black soil with pH 6.8-8.5. The plant can be cultivated under

either irrigation systems or rainfed condition. The most common method of planting mulberry is to use cuttings, but seeds are also used. Depending on the type of cultivation, the plant is grown as bush, tree or a middling. Mulberry grows to a height of 20-25m and a girth of about 8 cm (in the case of Morus serata).

Parts of mulberry plant include stem, bud and leaf. The stem has different colors. One bud is found on axial of a leaf. Sometimes two to three buds are found on either sides of the main bud and are known as accessory buds. Its leaves vary with varieties from simple to alternate stipulate.

Different farm implements and chemicals are used in mulberry agronomy. These include jamba, forketa, rake, pruning saws and garden fork, pruning sickle, stake, konchera, spring balance, axe, hand lens, pH meter, meter, chemicals, insecticides, fungicides, disinfectants, watering can, wheel barrow, hammer, bamboo baskets, pruning shear, labels, string, spade, bush knife, fertilizers, urea (46%N), DAP and FYM.

Dormancy

Dormancy is the resting stage of buds under extreme weather conditions. The buds under this condition do not sprout and are thus known as resting buds.

Causes of dormancy are believed to be harsh temperature, phototropism, nitrogen deficiency, and inactivation of enzymes due to accumulation of carbohydrates. Dormancy can also be caused by auxins present in buds. Terminal buds have more auxins than lateral buds.

Dormancy can be broken mechanically by bending branches after leaf harvest, by chilling treatment; that is by subjecting buds to low temperature of 0^0c -6^0c, and by the effect of chemicals such as methyl cooperate as reported by Iwata (1970).

Propagation

Mulberry can be propagated by seeds (sexual propagation) or cuttings (asexual propagation).

Sexual propagation

In sexual propagation, mature seeds are collected, washed and dried. An area under shade is dug, manured and prepared for seedling nursery. Then viable seeds soaked in hot water for a day to soften a hard testa for easy and successful germination are sown in rows. Seedlings are thinned when they grow to a height of 3.5 to 5 cm. They would be subject to sun light during cool hours. Transplanting is done with a distance of 22.5 cm three months after sowing. These seedlings grow for one to two years are then transplanted to field or used for grafting.

Asexual propagation

This can be done by cutting, grafting or budding.

Cutting: cuttings are most commonly used in the asexual propagation of mulberry. Nutritious, high yielding, fast growing, pests, diseases and drought resistant leaf cuttings should be used.

Properly matured and thick shoots with active and well-developed buds are cut from selected varieties. Cuttings taken from parts with high carbohydrate content root more readily and profusely than cuttings from parts rich in nitrogen. Tender portions from upper and over-mature parts at the base need to be rejected. Cuttings of 7-10cm long, slant cut with three to five active buds, should be produced.

Size of direct field plant or nursery bed must be determined before cuttings are planted in slanting position at a distance of 7-15 cm. After 8 months, cuttings are transplanted to the field depending on the type of the plants to be raised.

Roots of cuttings are formed either naturally or artificially. For poor rooting plants, certain growth regulator hormones are applied to stimulate rooting. These hormones include Indole Acetic Acetic (I.A.A.), Indole Butyric Acid (I.B.A.), Naftalin Acetic Acid (N.A.A.), and Dychlorophenoxy Acetic Acid (D.A.A.). Chemicals like restone and seradin are also used.

Grafting: Grafting is inserting rooted plant in to the same or allied species to bring about organic uniformity or union between the two species and finally make them grow as one. The branch that is inserted is known as scion and the plant in to which another plant is inserted is stock. The stock is usually an indigenous plant that is well acclimatized to the local conditions. Selection of stock and scion is very important. Grafting, thus, facilitates the propagation of a variety which has desirable qualities which can not be propagated by other methods. There are three types of grafting: shoot grafting, root grafting and bud grafting.

Budding: Budding involves removing one bud from stock and putting in to another stock. It is used only when the material is scarce. Patch budding, t-budding and ring budding (flute) are the types of buddings. In addition to grafting and budding, **air and ground layering** are used to propagate mulberry plants.

Polyploidy, which is the result of mutation, also helps to produce mulberry plants; some of which are drought and disease resistant and high yielding varieties.

Mulberry field can be managed by weeding, intercropping, irrigation and mulching. The plants can be top-pruned at 1m, medium pruned at 50 cm or low pruned at ground level.

Quality of mulberry leaves

Growth of silkworms depends on the quality of leaves fed to them. The leaves which are best relished and utilized by the worms are those containing more moisture, protein, sugars and carbohydrates. These nutrients can be obtained in young, succulent, and under 2½ months old plant leaves. It is advisable to harvest leaves at optimum stage of development and maturity. Furthermore, for vigor and proper development of worms, over matured and yellowing leaves are very poor in quality and can spell danger to the rearing if mixed with succulent leaves and therefore be picked up at the time of feeding.

Irrigation, nitrogen fertilization, close spacing and pruning help mulberry plants grow vigorously, and leaves harvested from such plants are nutritious and uniform in quality.

Leaf harvesting

Mulberry leaf is harvested from trees or bushes in the plantations, and is stored carefully to keep it fresh for silkworms. There are three methods of harvesting leaves: individual leaf picking, branch cutting, whole shoot harvesting. In individual leaf picking, individual leaves are picked from the plant, where in the other methods, the branches and entire shoots are cut and fed to the worms. These methods help to train the bushes.

Leaf quality is affected by withering. It is important to harvest leaves during cool hours and preserve them with care. As the nutritional requirement of young silkworms is different from requirement of old ones, tender leaves near the tip of branches are fed to young worms while mature leaves are fed to old worms.

After each harvest, the plant is allowed to stay 35 to 45 days with out picking leaves. Cultivation operations like digging, fertilizer application and weeding have to be done repeatedly after each harvest. Farm Yard Manure (FYM) is applied at least twice a year. The suitable time for harvesting leaves from the garden is either in the morning (till 10:00 AM) or late in the afternoon (from 4:00 PM-6:00PM).

Leaf preservation

It is important not only to produce highly nutritious and succulent leaves but also to preserve them fresh till they are consumed by silkworms. After harvest, moisture loss is very rapid, and this affects the edibility or palatability of leaves for silkworms.

To increase relative humidity in the rearing house and prevent withering of leaves, sprinkling water in the rearing house; using ventilators and fans; soaking sacks in water filled pails and hanging them on the windows are advisable. Fresh & succulent leaves harvested from the plants should be collected in wet sacks or in bamboo baskets lined inside and covered with wet unstitched sack materials. These leaves are transported to the rearing house where they should be immediately preserved under a wet cloth which should be kept wet all the time by sprinkling water on it repeatedly at intervals. Leaves preserved as such remain fresh with high moisture and protein content and are easily digestible to worms.

Practical

1. Investigation / observation of diseases & pests of mulberry
2. Identification and use of garden implements required for mulberry cultivation.
3. Preparation of nurseries .
4. Propagation of mulberry- preparation of cuttings and grafts and planting them in nursery- maintenance of nurseries.
5. Different method of planting mulberry under rainfed and irrigated conditions.
6. Irrigation- method of irrigation- numericals in water requirement of mulberry.
7. Manures and fertilizers- their identification- calculation of dosages to be applied to a given area of mulberry plantation- methods of application.
8. Identification of common weeds.
9. Pruning- different methods of pruning mulberry followed in India.
10. Harvesting- estimation of leaf production- different methods of harvesting mulberry leaf - farm recodes- their maintenance.

PartV. Cultivation & management of Castor (Recinsus Commnis): feed plant of Eri silkworm (philasomia ricinii) - 2 units

1. Uses of castor plants
2. Land preparation for castor plants
3. Planting seasons and spacing
4. Selection of castor varieties for quality leaf production
5. Application of recommended farm management practices for castor
6. Disease and pests' observation on feed plants
7. Pruning of castor and use of byproducts
8. Leaf harvesting and preservation method to feed silkworms

Food plants of Eri silkworm

Being polyphagous, eri silkworm feeds on several varieties of feed plants, which are mainly of Euphorbiaeace family. Among these are castor or era, Kesseru, tapioca/cassava, gulancha phool/champ, barkesseru, and papaya. The most important ones are castor (Ricinus communis), kesseru (Heteropanax fragrans), payam(Evodia flaxinifolia) and tapiopa/cassava (Manihot utilissima). Castor is the best among these feed plants. Eri silkworms reared on castor leaves yield large cocoons rich in silk content.

Castor and kesseru grow wild around villages or near rearers' houses in many areas. Thus, a rearer often collects leaves from scattered castor plants or kesseru trees.

Castor

Types and sowing methods

Castor may be grown as an annual or perennial plant. Its leaves are commonly seen with two colors: pale green and violet. Both are equally suitable for feeding eri silkworms.

June-October and March-April are preferred sowing seasons for castor. Sowing may be done in any area where rainfall has become scanty. Land preparation including manuring should be done beforehand.

Germination of seeds and growth of castor plants are greatly influenced by heat, light, moisture and aeration. Under optimum condition of heat, light, moisture and aeration, seeds generally germination within 7-10 days. Germination, however, takes longer time when temperature is low and moisture is less. So, it has to be cultivated like any other garden plants. Seeds are sometimes broadcast at rate of 9-10 kg per acre. But the best method is to sow 2 seeds in a hole, either 0.9-1.2m or 1.5-1.8m apart in rows. A stick, about 1½ inch thick and 8 inches long, may be used to drill holes and for sowing seeds.

The first thinning operation is undertaken when the seeds are broadcast, and the spacing is adjusted to 0.9-1.2m between plants. In the case of perennial plants, another thinning is done when the spacing is adjusted to 1.5-1.8m between plants. If, for some reason, germination is not as expected or the new plants appear weak, they should be uprooted and fresh healthy seeds should be sown in their places. The objective of thinning is to cultivate the healthiest plants and give proper spacing among plants.

To feed worms, leaves should be harvested from healthy plants. Dry leaves and twigs must be removed and plots should be weeded frequently to keep them clean.

Soil and manure

For good cultivation of castor trees, light clay soil is required. However, light sandy soil is always preferable to clay soil for better production. Since potash in the soil is necessary, it is replenished by adding ash of burnt weeds, leaves, stalks and stems. Cultivation of leguminous plants like sunhemp, acacia, cowpea, mung, and matakalai may be done before planting castor to incorporate nitrogen and humus in the soil. Castor and mustard oil cakes may be used as manure. A dose of lime is necessary when any manure with oil contents is used every two or three years. Well-decomposed FYM is the best and the cheapest organic manure in some places.

Inorganic fertilizer may be applied by top dressing either at the beginning or at the middle of cropping. Green manure may also be applied when the plants have grown two to three feet high.

Variety and Spacing

Selection of suitable varieties is essential for successful rearing of silkworms. Castor having non-powdery stems and leaves are better than those with powdery stems. However, short life plants cultivated for seeds may not be much suitable for rearing silkworms as there may be shortage of leaves at peak rearing period. Varieties less susceptible to wilt and root rot disease and tolerant to jassids should also be selected. Spacing of 1.5 m x1.5 m or 2.0 m x 2.0 m is also practiced on hilly lands and slopes where perennial castor plants are cultivated. Such spacing facilitates cultivation of cereals or vegetables as an intercrop along with castor.

Seed harvesting

Castor seeds do not become ready for harvesting simultaneously. This is because all the capsules on the fruiting branch or spike do not mature uniformly. So, the crops should be harvested when a few fruits or capsules show signs of drying. In some regions, the whole spike or fruiting branch of castor plant is stripped off when most of them dry. This method is not good because a large number of premature and partially dried fruits or capsules are harvested with the ripe fruits. Therefore, the quantity and quality of the produce is reduced. Kernels of immature fruits are light in weight and poor in oil content. Experiments show that seeds from mature capsules yield 5% more oil than seeds from immature capsules. Mature capsules shed their seeds if harvest is delayed until the fruits are fully dried on the plants. If castor seeds are collected when they are dry, more labor will be required for frequent pickings, and cost of collection will be quite high. So, the solution to this problem is to grow strains whose seed maturity comes at one time. Even then, it will be economical to harvest the crop only when the fruits in the spike are ripe. More quantity of matured and better seed is obtained in this way.

Pests and Diseases of castor

A number of insects attack castor leaves. These include castor semi looper, capsule borer (red hairy caterpillar), caterpillar (hairy caterpillar), mealybug, and castor jassid. These insects attack foliage, shoot, and capsules.

Many pests are effectively checked by dusting 10% DDT or BHC, or spraying 0.03% endrin with calcium ersenate, 0.1%malathion and 0.05% parathion insecticides. In early stages of infection, egg masses and caterpillars should be collected and destroyed. When the insecticides are used, leaves should be cleaned by washing thoroughly before feeding them to worms. Other control measures include ploughing the soil to expose and ill the pupae, handpicking and destroying moths, trapping and destroying caterpillars by digging trenches around and across infected field.

Seedlings blight, rusts, alternaria blight, and cercospora leaf spot are the diseases affecting castor leaves.

Seedling blights

Seedling blight is a disease caused by a fungus, phytophtora colocasiae racib. It attacks leaves of castor seedlings and other plants. This disease can be effectively prevented by avoiding damp and low-lying areas for plantation and by providing good drainage. Spraying Bordeaux mixture also controls the disease effectively. However, leaves should not be fed to silkworms immediately. We should wait at least for 10-12 days from the date of spraying. The symptom of the disease is a round patch of dull green color changing to yellow and brown spots at later stages.

Rust

Rust is caused by a fungus called Melampsora recini (Bv) pass. It attacks leaves causing them to wither and dry up prematurely. It is controlled by spraying the crop with sulfur.

Alternaria blight

Alternaria blight is caused by alternaria recini. It attacks stems, leaves, inflorescences and capsules. The affected parts are covered with a bluish green or sooty growth. It becomes extensive during rainy seasons and is transmitted through seed externally and internally.

Cercospora leaf spot

Cercospora is caused by caused by Cercospora ricinella Saci and Beri. The disease attacks leaves. Leaves become covered by many round or irregular diseased spots which wither and dry up. Bordeaux mixture or other copper fungicides may be used to control the disease.

Practical

1. Land preparation
2. Planting
3. Observation of diseases & pests
4. Leaf harvesting & preservation

Part VI. Silk Processing

Silk processings are yarn making,twisting,deguming,dying,weaving (knitting),finishing,sewing.

Yarn making

1. selecting cocoons be done fierst.

dirt,dryness,ratio,size

dirt,ratio, sizeare influense of yarn thickness,slaves and neps.

Dryness have influense for transportation and keeping.

Dirt is disturving yarn comes from cocoon.cut yarn and come out with slaves and neps.Ratio and size are key quality of cocoons.high ratio and big cocoons comes yarnthicker.row ratio and small cocoons yarn comes thinner.

So selection cocoons befor make yarn processing is important.

1. Drying of cocoons (Eri & mori cocoons)

eri cocoon

a.killing pupa

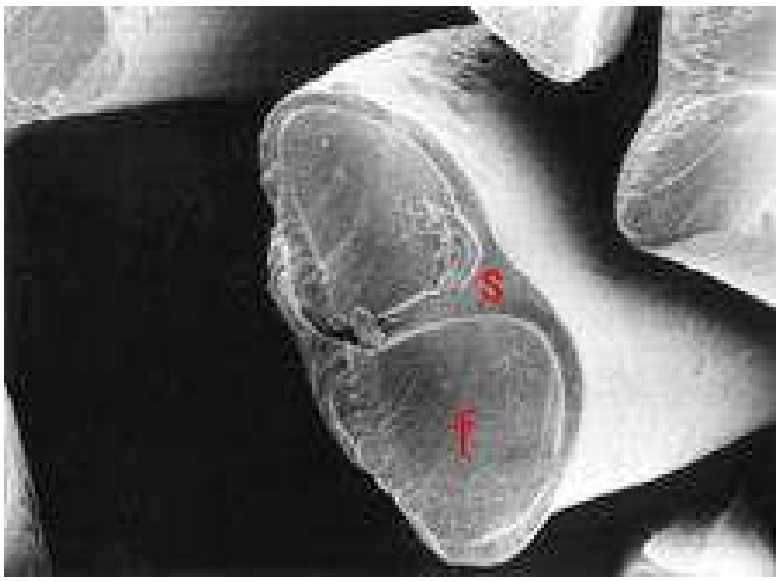
drying purpose are killing pupa, if pupa is surviving after two~three weeks,moths are coming out and making hole from cocoon .mulberry cocoon become cannotreeling,erisilk cocoon hole be disturbing good quality yarn processing. processing way are keeping under the sun in 4days to 6days, or in drying machine or in drying tool,until dieing pupa.the tempreture for drying tempreture degree is maximum 120℃。

b..drying pupa

drying pupa purpose is long time keeping, if not enough drying pupa is crashing by the others weight and becomes dirty cocoon inside,not enough drying get mold by humidity.dirt of cocoon is disturving yarn spinning.standard of fresh cocoon pupa and cocoon shell ratio is 87:13,so after drying ratio is changing to 67:33.

mori cocoon

a.drying cocoon purpose is same as ericocoon.
b.diference is pupa and cocoon shell ratio
bivoltine fresh cocoon 80:20 ,dried cocoon 55:45
multivoltine fresh cocoon 85:15, dried cocoon 63:37



Cross section of cocoon fiber
s: sericin f: fibrin

2. Cocoon cooking (Eri & mori cocoons)
3. boiling water quality shoud be ph7.if ph7－should be adjustment ph7 with chemicals.
4. yarn is separated two parts,sericin and fibrine.sericin is 30% surface of yarn,fibrin is 70% in center of yarn.
5. serine is sticky then make cocoons.sericin quality is solid in nomal degree and humidity.by boiling change to soft and resolving,in over４０℃ water reeling yarn smoothly.
6. eri cocoon

a. fresh cocoon
using two bowls,one is for boiling and 15minutes,another one should be keeping over 40℃～60℃water. Cocoon always is in warm water then try spinning.

b.dryed
sameus fresh cocoon processing,differences is boiling time,30minutes.
Mori cocoon
Fresh
Using two bowls,one is for boiling.boiling time is 1minute,and another one keeps over40℃～60℃ water.
Dryed
Using two bowls,same as fresh cocoon,defferences boiling time is 3minutes.
.
Using baking soda.
Using baking soda ratio and boiling minutes

Ericocoon
Fresh 87:13,dryed67:33 cocoon shell weight 5%
Boiling time for fresh cocoon is 7minutes.
Boiling time for dryed cocoon is 15minutes
Mori cocoon
Only use for dirt cocoon.
Biboltine,multiboltine,fresh,dryed cocoon ratio is cocoon shell weight 5%.

3. Cocoon quality's & quality control in raw silk
4. Cocoon drying & cooking in the practical part
5. COCOON GRADING- DIRT, DRYNESS, PURE COCOON RATIO, SIZE
6. REELING
7. THREAD
   - COLOUR, THICKNESS, KNOT, UNFORMITY OFTHICKNESS, TWIST
     ESTABLISH ING OF ETHIOPIAN QUALITY STANDARD
8. INSPECTION SYSTEM

Criteria of ERIcocoon and ERI silk YARN inspection

1. ERI Cocoon

Item	**Reason for inspection**	**Criteria**	**Inspection method**	**Remark**
1. Dirt	Affect to the uniformity of thread	1. Clean 2. 0%~10% 3. 10%~50% 4. More than 50%	2% sampling With naked eye	
2. Dryness	1) Affect to the amount of thread 2) Risk of dirt from pressed pupa 3) Risk of mold	1. Enough 2. Not enough	2% sampling Cut and press pupa on the paper	
3. Pure cocoon ratio	Affect to the amount of thread	1. ~ 10% 2. 10% ~12% 3. 12% ~14% 4. 14% ~	2% sampling Weigh	
4. Size	Affect to the thickness of thread	1. Large 2. Medium 3. Small	5% sampling With naked eyes	

Floss
Double
Colour

2.ERI SILK YARN

Item	Reason for inspection	Criteria	Inspection method	Remark
1. Color	Affect to the color of cloths after dyeing	1. Raw white 2. Beige 3. Brown	10% sampling With naked eyes	
2. Thickness	Needs of classification for different usage	1. Thick ~ g/m 2. Medium ~ g/m 3. Thin ~ g/m	10% sampling or 100% Measuring	
3. Knot	Affect to the quality of cloths	1. 5 m/knot~ 2. 3 ~ 5 m/knot 3. ~ 3 m/knot	10% sampling With naked eyes	
4. Uniformity of thickness	Affect to the quality of cloths	1. ~ 200% 2. 200 ~ 400% 3. 400 ~ 600% 4. 600%~	10% sampling Measuring the ratio of the size at thickest part to the size at thinnest part with naked eyes	
5. Twist	Needs of classification for different usage	1. Strong 40~ times/m 2. Medium20~40 times/m 3. Weak ~20 times/m	10% sampling Untwisting with counting	

Eveness

9. INSPECTION TOOL DEVELOPMENT

Eri cocoon

Fine weight measure equipment unit 1g 10cocoons
10g 100cocoons

Eveness checking black boad

Length and weight mesure tool

mori cocoon

text reeling equipment

Fine weight measure equipment unit 1g 20cocoons
10g 200cocoons

Eveness checking black board

Length and weight mesure tool

10. REWINDING, TWISTING TOOL DEVELOPMENT

garabou,plying,twisting machine(GPT)

11. CONTAMINATION CONTROL

using ultra violet ray lump checks other materials.contaminated materials are looking other colours.

12. NATURAL DYEING

Natural (vegetable)dyeing meaning are dyeing by natural materials.

soil is using in west Africa and south America,colours are yellow,dark orange,brown,grey and black.insects materials are cotineel,luc,dyeing red.
plant materials areplant seed, flower,bud,root,leaf, and bark.
Natural dyeing material need moldent except soil and indigo.
Moldent materials are Alum,Fe,Titan,Copper,Tin,Chrome chemicals.but for pollution control, we are using Alum and Fe.

a.Red with alum moldent
Flower saflower,
Insect cotineel,luc
Root madder
Soil no information
b.Brown,beige with alum moldent
Leaf green tea,herbs
Seed coffee
Bark mangrove
Soil no information

b. Grey

any plant materials with Fe moldent

soil no information

c. black

pomegranate fruit skin with Fe

d.blue
leaf indigo
timber logwood
e.yellow
bud clove

dyeing

1. boiling materials
2. by the colour dakness,silk weight ratio silk1:material 0.1～0.5
3. keeping materials one night with water,boiling materials time is 30minutes～60minutes

preparation of moldent
weight ratio water 40:silk 1:moldent material(alum or Fe)0.05

4. moldent

silk material(yarn or fabric) should be moistened with water.

Heating water up to 40℃,put into water,heating up to 60℃ in over 10minutes and Light squeezing.

5. dyeing

weight ratio dyeing material liquid 40:silk1

silk materials should be moistured with water.

Heating dyeing liquid up to 40℃ then put into dyeing liquid,heating up to 60℃ in over 10minutes.washing to washing water clear up.drying in the shadow.

14. NATURAL DYEING TOOL DEVELOPMENT
15. NATUTRAL DYEING INSPECTIONS, FADE COLOUR BY SUNSHINE, SWEAT AND LAUNDRY

15. By products of sericulture

a. silkworm faces

good for human skin care

b. pupa

in equatorial Africa ,people eat well pupa,good food fish breeding,good food for baby animals,in pregnancy animals,un pregnancy female animals.

16. SILKWASTE AND DEFECTIVE COCOON PROCESSING

Wasted and defected cocoons are dirty so cannot open only boiling.so defected cocoons are should be deguming.

Defected cocoon processing

(ア)cutting and out of pupa

(イ)cut cocoon deguming

deguming weight ratio water40:cocoon 1: baking soda 0.3:soap0.1

after deguming should be washing water several times and drying under shadow.

(ウ)hand spinning material

(エ)open by hand make floss,jaket linner,blanket floss

(オ)machine processing material

floss material,machine spinning material

Processing

PRACTICAL - 4 units

1. Drying of cocoons (Eri & mori cocoons)
2. Cocoon cooking (Eri & mori cocoons)
3. Cocoon quality's & quality control in raw silk
4. Cocoon drying & cooking in the practical part
5. COCOON GRADING
6. REELING
7. YARN GRADING
8. SPINNING (SILKWASTE, DEFECTIVE COCOON PROCESSING)
9. TWISTING
10. NATURAL DYEING
11. TOOL DEVELOPMENT
12. CONTAMINATION CONTROL

Part VII. Sericulture Development & Extension

Ethiopia's bimodal rainfall pattern, ambient temperature and other agroecological factors provide a fertile ground for mulberry and caster seed cultivation and silkworm production.

Mulberry commonly grows in urban and per urban areas where people cultivate for its fruit and life fencing. Castor tree is very common plant growing widely in compounds of rural and urban areas of the country. It also grows on wastelands, grave yards, along the road, sewerage and waste disposal areas.

Sericulture development by both eri and mori silkworms although old agricultural practice in East Asian and European countries has been introduced into the country very lately. It was initiated by Melkasa Agriculture Research Centre 20 years ago.

However, the technology has been disseminated to beneficiaries since 2001. The SNNP Regional Bureau of Agriculture & Rural Development is the first to promote sericulture technology to the rural poor farmers among all the regions. Other regions namely Amhara, Oromiya and Tigray are undertaking preliminary operations by their own initiative since a year.
Apart from these, interested individuals in and around urban and per urban areas of Awassa, Nazareth, Addis Ababa, Debrezeit and Bahir Dar are involved in the development programme.

Sericulture is a sideline activity by the farming community and integrated farming by investors. Considerable quantity of dried cocoons has been produced both by farmers & investors in the last 2 years. According to the recent report over 3000 kg of dried cocoon is collected out of which over 95% of the product is marketed to Addis. However, the quality of the cocoon in certain cases is inferior due to lack of knowledge and experience in producing & handling of cocoons.

Development Institutions

Effort has been exerted by the ministry of Agriculture and Rural Development (MOARD), which is the overall responsible institution to promote sericulture industry in the country. The MOARD has made significant efforts in a years time which include:

1. Development of Sericulture business plan, which is under implementation.
2. Sericulture development policy & strategy has been developed.
3. Sericulture development and technology package has been prepared
4. About 2.75 tons of two mulberry varieties were imported and planted at Alage ATVET for multiplication
5. Design for construction of Silkworm rearing house and grainage was prepared. The construction will be ready for use in 2005/6.

6. Technical assistance has been obtained from JICA for about 6 months upon agreement with JICA & the government.
7. Cooperation agreement was made with South South China Cooperation. This focus on organizing of Study tour, on-the-spot, short term and long term training, provision of sericulture processing equipment and tools, assistance in establishing national grainage (seed production) center and silk processing unit and assistance on market development.
8. The government committed to sponsor the purchase of cocoons from producers until the private sectors get involved with the business.

The Regional Agricultural & Rural Development Bureaus are responsible for the development of sericulture in their respective regions. The bureaus plan activity programmes, provide training and extension services, supervise and render technical assistance to the extension staff and farmers. Of all the regional bureaus the SNNP bureau of Agriculture & Rural Development has become a pioneer region to organize trainings both for development agents and farmers, supplying required equipment for silk rearing house, provide financial assistance for construction of rearing houses. The bureau also secured over Eth Birr 2.5 mil to promote the technology and cater loan services to farmers who pursue to expand their development programmes. The Bureau has identified about 30 weredas and started to exercise the development activities aggressively in these weredes.

The Amhara Regional Bureau has also conducted a number of workshops and trainings on the programme. A number of households are known involved in the activity.

Sericulture extension

The extent of sericulture extension unlike crop & livestock extension is a relatively new activity in the country. Currently, MOARD has developed a package on sericulture development aimed at promoting cocoon production, mulberry cultivation and at encouraging land owned or landless farmers to participate in sericulture activities. Many farmers both in food secured and insecured areas are expected to benefit from the extension package in the coming few years.

The objectives of the sericulture extension package include:

- To strengthen knowledge & skills of farmers.
- To generate income through production and sales of cocoon.
- To supply raw silk to the local textile industries.
- To generate foreign exchange earnings through export of cocoon & silk products.

The aforementioned objectives would be attained by cultivating mulberry trees as food plant for mulberry silkworms, rearing of silkworms, mounting and harvesting of cocoons, sorting of cocoons for reproduction and production etc. The package due attention mulberry silk farming because cocoon quality is higher, commands higher price and more profitable than the ericulture.

Sericulture package dissemination system

The following systems are expected to lead to better acceptance of the technology & increased production.

1. Provision of training

Training is one of the limiting factors for the promotion of sericulture development. There is no formal training centre for sericulture except non- formal training that hold at Melkasa Agricultural Research centre and 6-10 hours lecture in ATVET Colleges.

Short-term training, which lasts from 20-30 days, will be organized for training of trainers to implement the package. The training would be practical oriented and skill development. Such training will be provided to Wereda experts. The Wereda experts inturn are expected to train the beneficiaries.

2. Organize awareness creation forums

A forum such as field or farmers day would be organized at farmers silkworm rearing houses or demonstration farms. The forum is expected to be appropriate media to transfer the necessary knowledge & skill to needy farmers.

3. Strengthening of extension services

The extension services on sericulture like other agriculture extension activities will be centering the Farmers Training Centers (FTC's) Modules of the package would be developed to effect the services. Subsequent training and/or in-service training will be organized to the DA's to capacitate them with skill that will enable them technically assist the farmers.

4. Provision of input

Inputs that are required for rearing silkworms will be made available for purchase from suppliers and/or for home construction provided that prototypes are ready for use. Silkworms can be obtained from the nearest demonstration centres or from Melkasa Agriculture Research Centre. Mulberry cuttings of indigenous type for the time being can be obtained from residents in urban and per urban areas and also from the nearby mulberry farms of investors. New varieties of Mulberry and hybrid silkworms can be supplied to the producers from Alage ATVET starting early 2006.

5. Market development

Market as in other agricultural programmes is a key factor to sericulture development. Market will be facilitated to encourage the farmers to produce cocoons in a sustainable way. The government is committed to sponsor the purchase of cocoons from framers until the private sectors involve into the trading and processing businesses. Purchasing of cocoons will be managed both by the Agricultural & Rural Development Bureaus or by the Regional Commission of Cooperatives or by any representative organ of the government. Beside these, government affiliated NGO's will also be involved to encourage the producers.

6. Provision of credit

Credit will be facilitated for mulberry cultivation, construction of silkworm rearing houses, purchase of rearing equipment and tools and also for marketing the commodity. Smallholder farmers will be served through microfinancial institutions or from other source. Grace period should be given to the farmers to start back payments mainly because they are new to the technology and lack experience and stills for quick production of the item and generate income.

Part VIII. Additional course topics

a) Economics of sericulture
By MARD DATE Ethiopian culcuvated land are 86.5milion ha,irrigable land 3.5 milion ha.
Economics of sericulture Eri-silk farming
based on date at DEBREZEIT DAILY FARM sericulture dept.
planted 1ha castor field march 2004,the farm started erisilk rearing in june 2004,the farm harvested castor leafs 5times until march 2005,castor trees stopped growimg,only survibing.
The farm cuted all castors.the agricultural conditions were irrigated and non fertilizer.
The farm harvested products and income from june 2004 to may 2005 was this.

Eri dryed cocoons	670kg×30birr	20,100birr
Castor dried timbers (estimate)	54,750kg×0.1birr	5,475birr
Castor seeds(estimate)	700kg× 4birr	2.800birr
Eri dryed pupa(estimate)	1,340kg× ?	?
Total		28,375birr
4workers cost	3,600birr/year×4	14,000birr
irrigation and rental land cost		2,400birr
building and tray cost		5,000birr
total		21,800birr
profit		6,575birr

For household、workers cost is household income.14,000birr＋6,575birr＝20,575birr

Economics of the post-cocoon operation

1kg of erisilk yarn, row material silk ratio33% from dryed cocoons		30birr/kg	90birr
fire wood for boiling cocoons			5birr
100g spining charge	12birr/day	12birr×10days	120birr
total			215birr

yarn deguming cost for 1kg			
make hunk			10birr/kg
fire wood for deguming			10birr/kg
natural soap	1birr/500g	10%of silk weight	0.2birr/kg

baking soda	2.5birr/100g	30%of silk weight	7.5birr/kg
water :silk ratio 40:1	deguming water＋2times washing water	120L	?

yarn natural dyeing cost for 1kg

fire wood for dyeing			10birr/kg
alum (moldent)	20birr/kg	5%of silk weight	1birr/kg
dyeing material	100birr/kg	30%of silk weight	30birr/kg
water :silk ratio 40:1	moldent,dyeing,washing 2times	160L	?

Economics of mulberry silk farming
In Japan mulberry field cultivated non irrigation area.irrigable area cultivated rice.
First we consider irrigation and rainfall.Irrigable water amount＋rainfall amount.
Leaf harvesting amount is providing water amount.Mulberry tree growing for sericulture, Irrigable area must waiting minimum
Second comparative production efficiencies is by farmers?
Distance from cocoon production site to factory should be close distance.Cocoon is fresh Product,should be drying urgently. If production site to factory is long distance,Producers are should trying reeling themselves.

b) Marketing of cocoons & value added silk products
Marketing of cocoons
Domestic cocoons market only has inspected cocoons.
Current dried cocoons price 30birr/kg is expensive than other countries.
But other countries processing cost is high and didn't inspected.
World biggest silk production country china and Asian products are don't care the pollution. we will try controlled quality for environment care. Such as degumming by baking soda, natural dyeing ,energy sources are solor,timber.
Our products priority than compare countries products is organic products.
Under controlled organic products have big possibility to exporting.