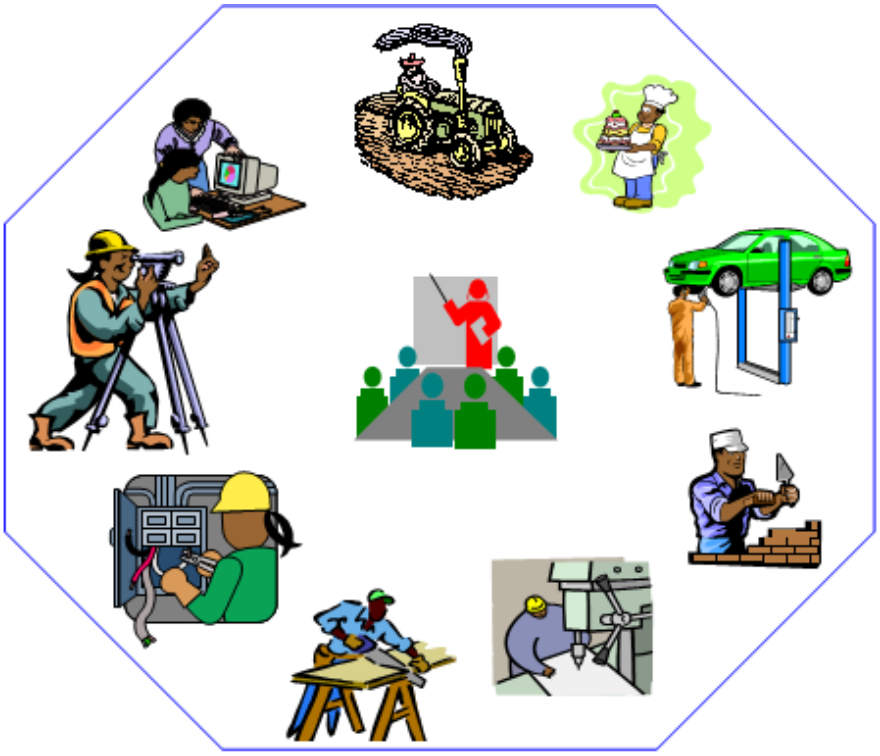
Animal production Level III

Based on **March 2018**, Version 3 OS and March. 2018, V3 Curriculum



Module Title: Assisting and Performing Seri-culture Activities

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Table of Contents page

L #73	LO #1 Participate in silkworm feed plant production

Instruction sheet

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Identifying and conducting silkworm feed plant agronomy
- Identifying materials, tools, equipment and PPE.
- Assessing the origin and distribution of mulberry
- Identifying the morphology of mulberry plant
- Identifying mulberry plantation requirements
- Carrying out mulberry plantation activities
- Implementing mulberry plantation managements.
- Assessing castor varieties
- Identifying the morphology of castor
- Identifying castor plantation requirements
- Carrying out castor plantation activities
- Implementing castor plantation managements

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Identifying and conducting silkworm feed plant agronomy
- Identifying materials, tools, equipment and PPE**.**
- Assess the origin and distribution of mulberry
- Identify the morphology of mulberry plant
- Identify mulberry plantation requirements
- Carry out mulberry plantation activities
- Implement mulberry plantation managements.
- Assess castor varieties
- Identify the morphology of castor
- Identify castor plantation requirements
- Carry out castor plantation activities
- Implement castor plantation managements

Learning Instructions:

Read the specific objectives of this Learning Guide.

1. Follow the instructions described below.
2. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them.
3. Accomplish the “Self-checks” which are placed following all information sheets.
4. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
5. If you earned a satisfactory evaluation proceed to “Operation sheets
6. Perform “the Learning activity performance test” which is placed following “Operation sheets” ,
7. If your performance is satisfactory proceed to the next learning guide,
8. If your performance is unsatisfactory, see your trainer for further instructions or go back to “Operation sheets”.

Information Sheet 1: Identifying and conducting silkworm feed plant agronomy

1.1 Definition of terminologies

Sericulture: is the practice of rearing silk worms for the production of raw silk.

Silkworms: is the larva of a moth (Bombyx mori) that spins a cocoon of fine, strong, lustrous fiber that is the source of commercial silk.

Mulberry: is a plant/tree of genus Morus having edible fruit that resembles blackberry and the leaf are the most important feed for mulberry silkworm.

Cocoon: is silky envelope spun by larvae of silkworm protect pupas.

Silk: a fabric made from the fine threads produced by silkworm.

Mounting: is transferring mature silkworms from rearing beds to montages to start spinning. Spinning starts 8 days after worms get into fifth (5^{th}) stage.

Incubation: is an important step for rearing. Incubation also: seed warming" by which the developing silkworm eggs (embryos) provided with proper environmental condition so that the embryos can develop normally and the eggs hatch uniformly.

Sorting: Selecting of normal cocoons from these defectives for more processing.

Reeling: - The removal of silk yarn from the cocoons.

Re-reeling: is making raw silk skeins of standard size and weight and done to get a firm and strong yarn.

The art of silk production called sericulture that comprises cultivation of mulberry, silkworm rearing and post cocoon activities leading to production of silk yarn.

Sericulture provides

- Gainful employment
- Economic development
- Improvement in the quality of life to the people in rural area
- Plays an important role in anti-poverty programmer
- Prevents migration of rural people to urban area in search of employment

Several developing nations like China, India, Brazil, Thailand, Vietnam, Indonesia, Egypt, Iran, Sri Lanka, Philippines, Bangladesh, Nepal, Myanmar, Turkey, Papua New

Guinea, Mexico, Uzbekistan and some of the African and Latin American countries have taken up sericulture to provide employment to the people in rural area.

Silk is a continuous protein fiber, which forms cocoon. It made by silk mother's larvae. It produced in an agro-based village or large-scale industry. The technology established on a small area. Silk is very thin but strong, durable, sheen, granular and beautiful. It is the only natural continues filament in the manufacture of textiles.

The economic importance of silk are:

- Its use as an alternative to marketable agricultural products such as coffee and pulses
- Creating job opportunity for people of all ages and gender categories, and hence income generating activity for ancillary units Minimizing number of migrants from rural areas
- increasing productivity per unit area of land within a short period with low cost investment, and fetching high demand by users who range from local weavers to top world fashion designers

Mori-culture is the cultivation of feed plant, such as mulberry and castor bushes, for silk worms. Once the mulberry and castor plants established Seri-culture chain begins with the selection of healthy moths for breeding. Moths produce eggs that distributed to farmers who rear the silkworms and the farmers feed the worms continuously until they are ready to produce cocoon.

The cocoon yields supplied to realer where they may be hand-reeled with traditional machines or reeled with modern automatic machines

1.2 Food plants of Mulberry Silk worms

Silkworms eat only mulberry leaves and preferring white mulberry. They also will **eat** lettuce and the leaves of two **other** tree species: the dosage orange leaves, Colure pomifera; and Tree of Heaven, Ailanthus latissimi.

Each of the silkworm species is specific in its feeding habits. Cultivation of Silkworm food plants is an agricultural activity. Raising and supply of improved variety of planting materials and maintenance of existing plantation

Increase the production, productivity and quality of leaf through adoption of packages and practices in existing plantation emphasizing on organic manure and cultural operation.

Mulberries have both male and female flowers on the same **tree**, but they can also be on separate **trees**. **Leaves** are about eight cm long, coarse, heart shaped, with toothed edges. Can be hairy on top and downy underneath. Some lower **leaves** and those on new shoots can be lobed, or with deep incisions.

Mulberry silkworm is mono phages insect, which reared on the leaves of mulberry only; the Morin present in the leaves helps to attract the silkworm.

Figure 1: Cultivation of Silkworm food plants

1.3 The variaty of mulberry.

A. Black and white mulberry

- Only one variety and few cultivars of black mulberry

- Unlike the black mulberry there are as many as 16 recognised species of white mulberry and dozens of cultivars, selected for feeding silkworms.

Figure 2: a) Only one variety of black mulberry. b) Recognized species of white mulberry

Mulberry (Morus in Latin) is the main feed plant of silkworm (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 universally distributed between 23^0 south and 45^0 north of the equator
- Mulberry is the basic food for silkworm
- The bulk of silk goods in the world produced from mulberry silkworms
- 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 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

Figure 3: Variation in the color, size, and shape of fruits in mulberry (black and white**)**

b. Red mulberry and Fruit of the red mulberry

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
- Mulching influence mulberry production.

1.4 Silkworms' feed plant agronomy

Mulberry farm established near the rearing house and it is better if it is uniform upland bund.

The plant prefers

- Loamy soil
- Alluvial
- Volcanic and black soil with pH 6.8-8.5.
- Mulberry grows to a height of 20-25m and a girth of about 8 cm (in the case of Morus serata)

The plant cultivated under either

- Irrigation systems or
- Rain fed condition

The most common method of planting mulberry are:

- Use cuttings
- seeds are also used

Depending on the type of cultivation the plant grown as:

- Bush,
- Tree or
- 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 found on axial of a leaf. Sometimes two to three buds found on either sides of the main bud and known as accessory buds. Its leaves vary with varieties from simple to alternate stipulate.

- Chemical used jamba, forketa
- Fertilizers, urea (46%N), DAP and FYM.

1.5 Dormancy

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

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

Dormancy 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.

Self-Check-1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Fill the blank space

1_____is the practice of rearing silk worms for the production of raw silk (2%)

2. _____the removal of silk yarn from the cocoons (2%)

3_____is silky envelope spun by larvae of silkworm protect pupas (2%)

4. List down the uses of sericulture contribution (3%0

_____,_____

_____

_____

5. Write the variate of mulberry plant (3%)

_____,_____,_____

6. Write the method of mulberry plant cultivation (2%)

_____,_____

7. Write the parts of mulberry plant (3%)

_____,_____,_____

8. Write the mulberry plant preferences (2%)

_____,_____,_____,_____

Answer the following question!

Note: **Satisfactory rating 9 and 17 points** **Unsatisfactory 9 below and 17 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = _____

Name: _____ Date: _____

Short Answer Question

Information Sheet 2: Identifying materials, tools, equipment and PPE

2.1 Introduction

There are different types of materials, tools; equipment, supplies and PPE used to perform different activities in sericulture development activity Therefore, identifying, selecting, using and preparing facilities, supplies according to the working activity are very important aspect in sericulture work.

2.2 Material used for sericulture are:

- White bird's father
- Local montages
- Karaka (egg cards and egg case)
- Disaffecting material
- Nylon string
- Plastic tube watering
- Chopstick
- Pegs
- Empty sack
- Cleaning supplies (detergent)
- Long sheet (record book)
- Lumber and plywood
- Hard cardboard
- Bamboo basket
- Cheesecloth
- Marker
- Black sheet cloth
- Bamboo try
- Plastic bag for seedling
- Paper bags
- Hand washing try

- Paraffin paper

2.3 Tools and equipment needed for sericulture

- Refrigerator
- Balance
- Ruler
- Stiner
- Beaker
- Petri dish
- Dropper
- Graduating cylinder
- Test tube
- Buckets
- Wheel barrow
- Shovel, spades, forks and hoes
- Try (rearing/feeding and seed)
- Rearing and feeding stands
- Cleaning net
- Pruning scissors
- Measuring tape
- Thermometer
- Humidity records with chart
- Hammer, saw nail,
- Forces hand lens
- Egg counter
- Chopping knife and chopping boards
- Hand sprayer
- Hydrometer

2.4 Modern montages sericulture are:

- Refrigerator

- Ventilator
- Foot cleaning tray
- Water bath
- Centrifuge
- Incubator
- Stop watch
- Basin stands
- Hygrometer
- Leaf chamber
- Electric heater or charcoal
- Ants well
- Mounting board
- First aid kit

2.5 Select suitable personal protective equipment used for sericulture are:

- Overalls
- Gloves
- Safety goggles
- plastic boots/shoes
- Sunhats
- Respiratory musk
- Helmet
- Aprons,

Protective clothing selected to prevent skin contact with virus-contaminated materials or environments. Consideration given to the type of work performed by the worker when selecting personal protective clothing.

Self-Check-2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Fill the blank space

1. List down at least ten material used for sericulture (5%)

_____,_____,_____

_____,_____,_____

_____,_____,_____

_____,_____,_____

2. List down at least ten tools and equipment used for sericulture (5%)

_____,_____,_____

_____,_____,_____

_____,_____,_____

_____,_____,_____

3. List down personal protective equipment used for sericulture (5%)

_____,_____,_____

_____,_____,_____

_____,_____,_____

Answer the following question!

Note: **Satisfactory rating 8 and 15 points** **Unsatisfactory 8 below and 15 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: _____ Date: _____ Score = _____

Short Answer Question

Information Sheet 3: Assessing the origin and distribution of mulberry

3.1 The origin and distribution of mulberry

Mulberry (Morus) believed to have originated in the northern hemisphere, particularly in the Himalayan foothills, and spread to the tropics of southern hemisphere (Benavides et al. 1994; Hou 1994). While reviewing the centers of origin of crop plants, Vavilov (1951) placed Morus L. further supported this northern hemisphere origin with subsequent migration into the southern hemisphere (Collinson 1989)

Most of the contemporary molecular studies also revealed an early diversification of Moraceae in Eurasia and subsequent migration into the southern hemisphere

The temperate origin of mulberry is further evident from the nature of the growth as at the end of each growing season the apical meristems of the long shoots abort and are abscised

Today, the genus Morus is present in all regions between 50N Lat. and 10S Let and from n China–Japan center of plant origin.

Excavations of early Tertiary Moraceae Fossils Sea level to altitudes as high as 4,000 m (Tutin 1996; Machii et al. 1999), which include

- Asia
- Europe
- North and South America
- Africa

Continental distribution of mulberry

- America has four species viz., M. insignis, M. celtidifolia, M. corylifolia, and M. mexicana (Table 5.3)
- India, there are many species, of which Morus alba and M. indica are fully domesticated while M. serrata and M. laevigata grow wild in the Himalayas

- China has 24 species but only four species viz., M. alba, M. multicaulis, M. atropurpurea, and M. mizuho are largely cultivated for sericulture purposes and the remaining are considered wild species.
- In Japan, out of the 19 species only M. alba, M. bombycis, and M. latifoila are mostly cultivated.
- In Africa, M. mesozygia reported to occur in humid, sub humid, and semi-arid areas. It grows well from sea level to an altitude up to 1,000 m (Le Houerou 1980)

The vernacular names attached with some of these species also indicates either their origin or their morphological distinctiveness. For instance,

- M. alba is called “white mulberry” because of the fruit and bark color.
- White mulberry native to China but has spread into several other countries
- M. nigra called “black mulberry” due to the dark red fruit it bears
- Black mulberry, a native of **Iran and** cultivated for its **fruits** in

  - ✓ South Europe
  - ✓ Southwest Asia
  - ✓ most important species in the Mediteranean countries

- The black mulberry (Turkish name “Kara Dut”) widely grown in Turkey for its delicious edible fruits
- Owing to the Mediterranean conditions, the northeastern part of Turkey, in particular Coruh valley, has notable populations of black mulberry
- The M. rubra is called “red mulberry” due to stem and fruit color
- Red mulberry is native to North America, and it has been cultivated in America since colonial times and its fruit made into wine and also the fruit considered a valuable agricultural and wildlife feed.

Likewise, based on the place of origin M. tartarica is called as “Russian mulberry,” M. serrata as “Himalayan mulberry,” M. mesozygia as “African mulberry,” M. celtidifolia as “Mexican mulberry,” M. microphylla as “Texas mulberry” and M. australis as “Chinese mulberry.”

Historical evidences show that the Chinese were the first to develop and reel silk from cocoon 4500 years ago. For nearly 3000 years, silk production in China kept secret, but gradually, the knowledge spread by Monks, prisoners or Smugglers to Korea, Japan, India and Southeast Asia.

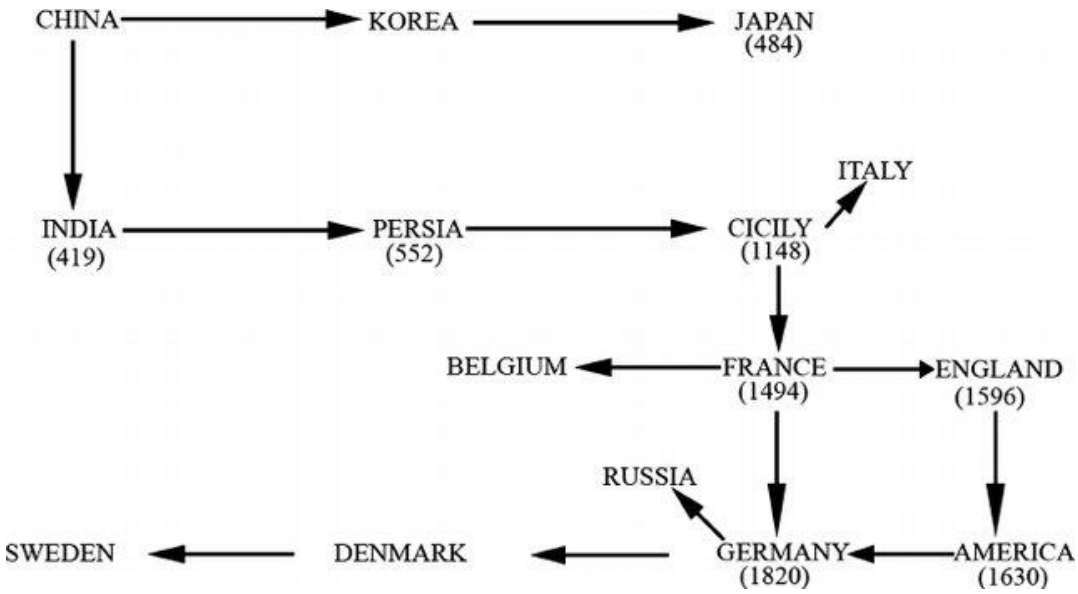


Figure 4: The historical distribution of mulberry plant

line diagram showing the domestication of the most widely grown mulberry species, M. alba , a native of China, to areas as far apart as India, Europe, and America (Reproduced from Sharma et al. 2000)

Self-Check-3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Fill the blank space

1. Mulberry (Morus) believed to have originated in the (2%) _____

2. Write the historical order of mulberry plant distribution (5%)

_____,_____,_____,_____

_____,_____,_____,_____

_____,_____,_____,_____

_____,_____,_____

3. ___ the first county to develop sericulture development (2%)

Answer the following question!

Note: **Satisfactory rating 5 and 9 points** **Unsatisfactory 5 below and 9 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: _____ Date: _____ Score = _____

Short Answer Question

Information Sheet 4: Identifying the morphology of mulberry plant

4.1 Introduction

Morphologically of mulberry plant is a fast growing deciduous woody perennial tree with deep root system. The morphology of Mulberry plant contended from leaf up seed.

4.2 Leaf

Wide variations in leaf morphology observed among different species and accessions within species. Leaves of white mulberry are:

- Simple
- Alternate
- Stipulate
- Petiolate
- Entire, or lobed
- The number of lobes varies from one to five

Leaves of the red mulberry are larger, thicker, blunt toothed, and often lobed. They are rough on their upper surfaces and pubescent underneath. The smaller black mulberry leaves are similar to those of the red mulberry morphologically, but with sturdier twigs and fatter buds

The shape of the leaf may vary according to the:

- Age of the plant
- Growth
- positions in the branches
- Period of growth, etc.

Leaves of wild mulberry species such as M. laevigata, M. serrata, and M. tiliaefolia considered too rough, leathery and thick to use for silkworm rearing

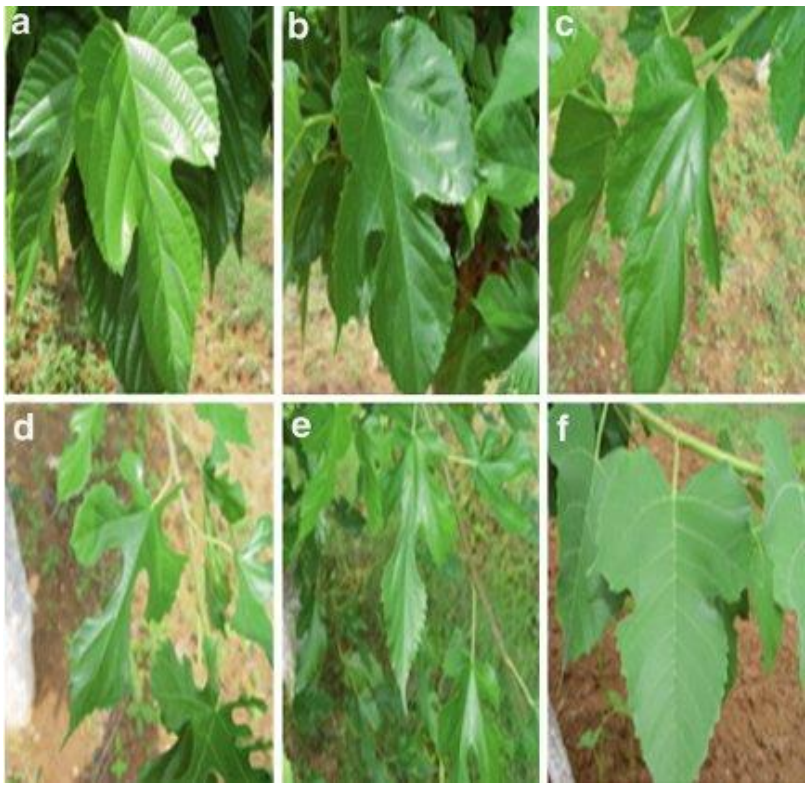


Figure 5: Variations in the leaf morphology of mulberry

(a) M. laevigata (b) M. laevigata

(c) M. Alba, (d) M. indica (e) M. indica (f) M. serrata

4.3 Flower

The mulberry trees are predominantly dioecious, monecious plants are not very rare. It reported that mulberry changes its sex depending on-

- Environmental conditions
- Physical injury
- Pruning

Presumed that mulberry possesses both male and female determining genes, but their expression determined by

- External stimuli Climate
- Internal stimuli such as physiological factors

Based on the observations some cultivars opined that dioecism evolved from monoecism in mulberry. Sexual reversal using hormones, chemicals, and growth regulators reported by several researcher.

The inflorescence in mulberry catkin with pendent or drooping peduncle bearing unisexual flowers. Male catkins are usually longer than the female catkins. Inflorescence of M. laevigata is the longest among the inflorescence of mulberry species, with ca. 5–12 cm long in males and ca. 5–6 cm long in females.

Male flowers loosely arranged and after shedding the pollen, the inflorescence dries and falls off. There are four persistent perianth lobes and four stamens, filaments incurved in bud.

Female inflorescence is usually short and the flowers arranged compactly. There are four persistent Perinat lobes. The ovary is single celled stigma is bifid. The ovules are pendulous. Pollination neomophilous.

4.4 Fruit

The fruit is a serosa's that composed of a collection of individual fruits (Achens). Once the female flowers pollinated, the white stigma turns into brownish colored and finally dries off. Subsequently, the fleshy bases of the Perinat swell and become completely altered in texture and color.

The ripened fruit is succulent, fat, and full of juice. Because the color of the fruit varies greatly from white to black with different color shades upon ripening the color of the fruit is not a reliable character to identify mulberry species.

White mulberries, for example, can produce white, lavender, or even black fruits depending, to certain extent, on the timing of harvest. If the harvesting of fruits delayed, the over ripened fruits of white mulberry turn into somewhat black.

White mulberry fruits are generally very sweet. Red mulberry fruits are sweet and usually deep red or almost black.

Black mulberry fruits are attractive, large, and juicy; with a good balance of sweetness and tartness, that makes them the best-flavored fruits in mulberry. The ripened fruits of all mulberry species are very perishable must handle carefully while harvesting and subsequent processing like transportation and marketing.

Figure 6: White mulberry frui Black mulberry fruit

Figure 7 : a) Fresh ripe black mulberry fruit fresh ripe white mulberry fruit

4.5 Seed

The seed is light yellow or brown in color, oval shaped with a nearly flat surface at the micro-polar region.

The seed coat contains two layers like:

- The outer hard and brittle layer called the teste
- The inner thin papery and slightly brownish layer called the **segment**.

Inside the seed coat, there is the kernel, which contains outer endosperm and inner embryo. Embryo consists of a primary axis (plumose and radicle) and two cotyledons.

Mulberry seeds difficult to germinate and may naturally show low rates of germination. Seeds require approximately 90 days of cold, moist stratification, which should initiated in mid to later winter. Prior to stratifying, **seeds** should soaked in water for 4 days, replacing water every 2 days.

On germination, the plumose gives rise to the shoot system and the radicle to the root system.

The size and weight of the seed vary from variety to variety. Generally, the seeds retain viability only for few weeks under room temperature, but if stored under controlled temperature and humidity, the viability prolonged for 3–6 months.

The optimum temperature for germination is 28–30C. Mulberry seed contains 25–35% of yellow dying oil.

Figure 8: Blak dried seed mulberry fresh ripe blak mulberry fruit

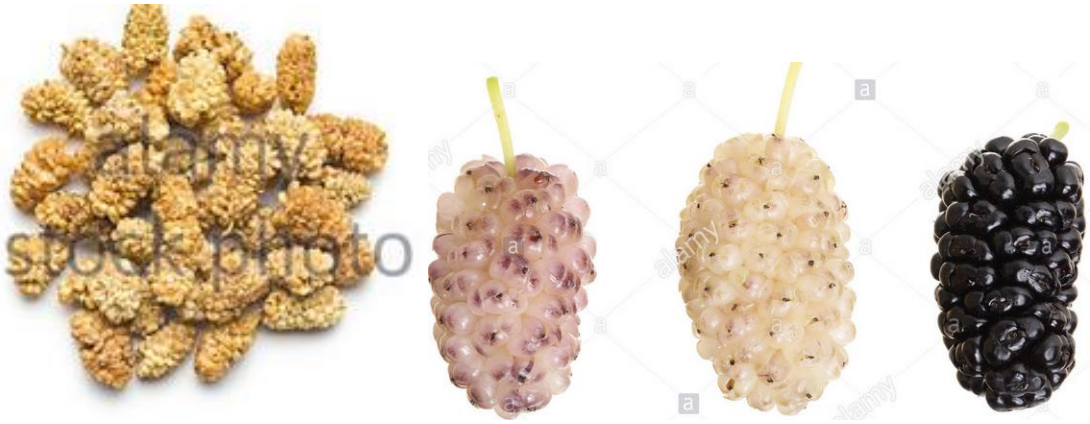


Figure 9: White dried meulberry seed Fresh ripe white Mulberry fruit

Self-Check-4	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Fill the blank space

1. Write the leaf morphology of white mulberry plant (6%)

_____,_____,_____

_____,_____,_____

2. Write the factor contribute for leaf sheep variation of mulberry plant (4%)

_____,_____

_____,_____

3. Write factor contribute for mulberry plant to changes its' sex (3%)

_____,_____

_____

4. Write the two layer of mulberry seed coat (2%)

_____

_____

Answer the following question!

Note: **Satisfactory rating 8 and 15 points** **Unsatisfactory 8 below and 15 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: _____ Date: _____ Score = _____

Short Answer Question

Information Sheet 5: Identifying mulberry plantation requirements

5.1. Mulberry plantation requirment

A. Mulberry plantation soil type requirment are:

- Flat
- deep fertile
- well drained
- loamy to clayey
- porous with a good moisture holding capacity
- The ideal range of soil pH is 6.2 to 6.8
- Mulberry grown in soil like:
  - ✓ Saline
  - ✓ alkaline and acidic soils after suitably amending the soils
- Preparation of land.

B. mulberrty plant growth habit and ecology required are :

- The fastest growing temperate trees
- Produces an abundance of excellent fruit every year
- Virtually pest and disease free
- One half responsible for the finest fibres known to man
- silk grown nearly everywhere that has soil and a source of high quality animal fodder plus quite a bit
- more

Figure 10: Mulberry for Permaculture/Polyculture and Agroforestry

I. Growing Range

Morus alba has a very wide distribution range in Asia and Europe

The origins of most cultivated mulberry varieties are believed to be in the China/Japan area and in the Himalayan foothills.

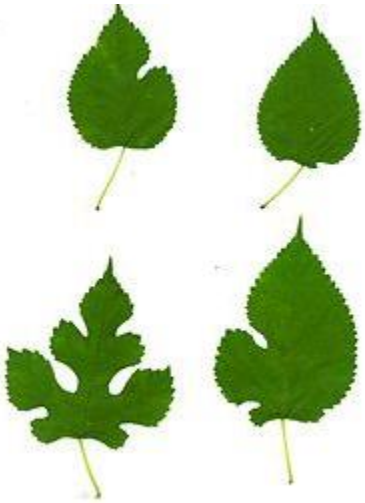


Figure 11: Morus alba leaf variation —

II Description mulberry plant

- A fast-growing
- small to medium-sized tree growing to 10 –20 m tall
- generally a short-lived tree although there are some specimens known to be over 250 years old

- Fruits of white at maturity on a few trees, but are usually dark purple and 3 to 6 cm long
- The fruits ripen from mid spring late summer (depending on species and cultivar).
- The leaves are usually shiny, dark green and smooth butnmyellowish green
- Most leaves are not lobed
- The juvenile growth is often lobed.

III. Ecology

Many small mammals feed on mulberries are:

- Birds
- Foxes
- squirrels and rodents
- Deer browse on the twigs, foliage and a range of insects inhabit the crowns of mature trees
- In experience Ladybirds are attracted to the Mulberry fruit
- Mulberry is often associated with Mycorrhizae like:
  - ✓ Glomus mosseae
  - ✓ Glomus fasciculatum

5.2 Mulberry reproduction type

A. Sexual Reproduction

The trees can be dioecious or monoecious, and sometimes will change from one sex to another. The flowers are held on short, green, pendulous, catkins that appear in the axils of the current season's growth and on spurs on older wood

They are wind pollinated and some cultivars will set fruit without any pollination. The White Mulberry is notable for the rapid release of its pollen, which is launched at over half the speed of sound!

This method is probably effective method for Red Mulberry and perhaps Black Mulberry.

White Mulberry grown from seed and is best sown immediately after fruiting. Cold stratification for 4- 16 weeks can improve germination rates. Layering is also reported to work well.

Figure 12: Male flower female flower

B. Propagation (asexectual)

There are many reports on the internet of how easy it is to propagate mulberry from branches Simply cut the branch from the tree and push it into the soil and presto!

5.3 Light Preferences

Mulberries thrive in full sun but can grow well in partial shade.

5.4 Water needs

The plants are drought tolerant but grow best and yield high in areas with rainfall between 600 -1500 mm/yr. In location with average annual rainfall of 580 mm they grow well without irrigation.

Mulberry growing well in wetlands and on riverbanks, as the plants are tolerant to sporadic water logging although they usually occur in non-wetlands.

5.6 Habitat

Morus alba commonly invades old fields, roadsides, forest edges, urban environments, and other disturbed areas. It grows well in natural forests, planted forests, range/grasslands, ruderal/disturbed areas and urban areas.

5.7 Hardiness

- Very hardy tree tolerating temperatures down to -36C but also comfortable in sub tropical and Mediterranean climates.
- Morus alba is the most cold resistant of the Mulberry trees

5.8 Climatic Limitations

Mulberries thrive over a very wide range of climates especially warm temperate but also Mediterranean, sub-tropical and tropical, where they can be grown as evergreens.

5.9 Location

The trees are tolerant of wind, drought, cold and partial shade so pretty much plant them anywhere. The plant is also quite salt tolerant once established. A few things to consider when choosing a location is that the fruit fall can extend 6–8 weeks and once mature it's practically impossible to harvest let alone consume all that fruit, so placing the tree in a place where the fruit fall will not be a nuisance is a good idea.

The trees can get large and will cast a heavy shade when mature so this should also be taken into consideration. We lift the lower limbs of our trees to allow space and light for a range of smaller trees, shrubs and herbs (see Mulberry polyculture later).

5.10 Feeding, Irrigation and Care

A. Feeding

Mulberry require little fertilisation. When planting out new trees top dressing the planting hole with 20–30 L of compost and repeating this in early spring for the first 2 years will be more than enough to get them going. After this they should be fine, especially so if you are growing the tree in polycultures.

B. Irrigation

The trees will grow faster and produce more fruit with access to water during the flowering and fruiting period. Young trees should be mulched well each spring and irrigated for the first 2–3 years with 30 L of water every 2–4 weeks without rain

The trees develop deep taproots that should be able to access ground water if available.

C. Weeding Mulching plants with a 10 -20 cm deep mulch each spring and pulling weeds that start to grow through in the summer is good practice when the plants are young. As the trees mature they grow well amongst other plants of all kinds.

D. Pruning

Mulberry are low branching. We have lifted the lower limbs of our trees to approx 5- 6 m high allowing us to plant under the tree and to allow easy access around the tree. The trees respond well to this type of pruning. If pruning young trees bear in mind the flowering and fruit buds develop on second year old growth.

C. Harvesting

The easiest way know of to harvest a White Mulberry is the shake and catch method.

Fresh fruit only keeps for a few days, and is best kept refrigerated if you don't eat them immediately. This is one of the main reasons you don't see much Mulberry fruit in the shops. The fruits can also be dried or frozen (never tried it personally).

5.11 Potential Problems mulberry plant

A. Invasive

This species is considered ecologically invasive in most of North America. The threat is to the native Red Mulberry (M. rubra) though hybridization. It does not seem to be a problem in Europe.

B. Pest and Disease

Mulberries suffer few disease and insect pests. The main pest to Mulberry is probably deer that will browse on the leaves of these plants, but this is generally only a problem with young trees and regrowth from coppice.

C. Allergies

The plant's pollen has become problematical in some cities where it has been blamed for an increase in hay fever.

Self-Check-5	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Fill the blank space

1. Write the soil types required for mulberry plantation and range of PH. (4%)

_____,_____,_____

_____,_____,_____

_____,_____,_____

_____,_____,_____.

2. Write the mulberry discretion habit (3%)

_____,_____

_____,_____

_____,_____

3. Write the small mammals that feed on mulberry plants. (3%)

_____,_____

_____,_____

4. Write the types mulberry reproduction type (2%)

_____,_____

5. Write the Potential Problems mulberry plant (3%)

_____,_____

_____

Answer the following question!

Note: **Satisfactory rating 8 and 15 points** **Unsatisfactory 8 below and 15 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: _____ Date: _____ Score = _____

Short Answer Question

Information Sheet 6: Carrying out mulberry plantation activities

6.1 Introduction

Sericulture is an agro-industry which means, combining both agriculture and indusrty final product is silk.

6.2 Soil and climate requirment for mulberry plantation

Mulburry grow practically on any type of land except on very steep lands. Good grwth obtained when raised on either flat land, gently sloping or undulating lands. On more sloppy or steep lands, necessary attention to proper soil conservation methods as contours drains, contour planting or even bench terracing should be given.

Mulberry cultivation done in wide range of soils, but best growth is obtained in loamto clayey loamsoils. The mulberry plany tolerate slight acidic condition in the soil. In the case of too acidic soils with PHbelow 5, necessary corrective measures through application of dolomite or Lime should adopted. In the case of alkaline soils, application of gypsum should bee resorted to for correction of the soil alkalinity.

Sincemulberry is adeep-rooted plant, the soil should be sufficiently deep up to about twofeet in depth. In respect of elevation, mulbrry thrives well up to about 4,000feet, above growth will be retard because of the cooler temperature.

6.3 Land preparation for mulberry plantation

The category of perennial crops and once it is properly raised during the first year, it can come to full yielding capacity during the second year and lasts for over 15 years in the field without any signficant deterioration in the yield of the leaf. Usually , flat lands are suitable for irrigated mulberry cultivation. If the slope is more than 15% suitable land development measures such as contour bunding, bench terracing,

In mulberry cultivation, the field should be preped by deep plowing uo to adpth of **30-45cm** inorder to loosen the soil and after with a country plow or tractor to bring the soil to fine tilth. Weeds, stones shuold be removed during the prepatory stsge. Abasal dose

of farmyard manure at **20 tonnes per hectare** is recommendde, which has to thoroughly incorporated into the soil

Farmlands not suitable location for mulberry cultivation by irregation are Raw sewage and untreated effluent, Lots abetting other gardens with intensive pesticide usage and Waterlogged areas and tobbacco grown land are

6.4 Selection of variety for mulberry production

The criteria for selection of variety includes:

- Fertility of the land
- Water avialability
- Region specificity
- Tthe extent of the garden and problematic soilss
- The yield potential of high yielding varieties can be best realized in high fertility soils
- Respond to intensive irrigation Wherever the size of the operation is bigger.

6.5 Planting material and plantation of mulberry.

Cultivation taken by

- Cutting and saplings
- Saplings are always better then cutting as planting material for quick and better establishment
- Two cutting/one sapling are planted at each spot in desired spacingm cutting are planted keeping one bud exposed while the saplings are planted in pits opened at the spot.

6.7 Preparation of cutting mulberry farming

- Cutting should be prepared from well matured 6-8 months old shoots of about 1.5cm in diameter
- Cutting of 15-20cm length with 3-4 heallthy buds are selected for plantation

6.8 Raising of saplings for mulberry plantation.

- Nursery beds withs a dimention of 5mx1.5meters are preped
- The land is dug to a depth of 30-40cm and the soil should be puverized well.

- FYM (farm yard manur) is applied at 15kg per bed
- mixed well with thwe soil some quintitiy of sand is also added to heavy (clayey)soils to make the loose and friable
- some quantity of thank silt or other well decomposed organic matter applied to sandy soils to increase the the water holding capacity
- Cutting should be planted in nursery beds with aspacing 15cmx 10cm.
- The full length of cutting ispushed into the soil keeping only one bud exposed above the ground
- It should be irrigeted twice aweek.
- Fertilizer is applied at 25:25:25(N:P:K0kg per hectare after 5-6 weeks when plants sprout well and the root system is established.
- In mulberry cultivation , saplings of about 80-90 days old can be used for planting
- uprooting the saplings,maximum care should be taken to avoid damage to the root system.

6.9 The spacing mulberry plants

In mulberry cultivation spacing requirment depends upon

- The soil condtions
- Slope
- Variety and convenience for inter-cultural operation

Spacing (cm)	Suitability	No. of plants/ha
90x90	Heavy soil, black soils, heavy rainfall areas	12,345
120x60	Sloppyland (hilly areas)	13,888
(90+150)x60	Suitable for mechanized farming	13,888

6.10 Planting of mulberry

Pit system is ideal in 09x90cm spacing . pits of 35cm^{3}are dug and left for one month, which is later filled with farm yard manur (FYM) and soil at 1:2 ratio. Tranches of 35cmx35cm are also covenient to take up plantation in mulberry cultivation. It is preferable to start the plantation during the rainy season in hilly areas, e cutting s of 20-22cm length are planted in each pit at aspscing of 15cm. cutting not sprouting I 4-5 weeks need to be replaced saplings to ensure the required plant density.

Self-Check-6	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Fill the blank space

1. ____ is an agro-industry which means, combining both agriculture and industry final product is silk (2%)

2. Write the criteria for select variety of mulberry for production (4%)

_____,_____

_____,_____

3. Write the factor infulence space required for mulberry caltivation (4%)

_____

_____

_____

_____

Answer the following question!

Note: **Satisfactory rating 7 and 12 points** **Unsatisfactory 7 below and 12 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: _____ Date: _____ Score = _____

Short Answer Question

Information Sheet 7: Implementing mulberry plantation managements.

7.1 Mulberry Cultivation and Management

Mulberry is a hardy plant capable of thriving under a variety of agro-climatic conditions wide range of soils, but best growth is obtained in loamy to clayey loam soils.

- Acidic soils with pH below 5 corrective measures through application of **Dolomite** or **Lime**
- **alkaline soils**, application of **Gypsum** for correction of the soil.

7.2 Mulberry plant water and temperature requirment

- Mulberry thrive well upto about 4,000 feet above which growth will be retarded because of the cooler temperature
- Grown under both rainfed and irrigated conditions.
- Mulberry generally thrives well in the soil having 40-45% water holding capacity
- Climatic conditions ranging from temperate to tropical located north of the equator between 28° N and 55°N latitude
- The ideal range of temperature from 24 to 28°C. Mulberry grows well in places with an annual rainfall ranging from 600 to 2 500 mm.

7.3 Weeding and Inter-cultivation in mulberry farming

During the initiol stage of mulberry plant establishment in the field, weed growth should be kept to the minimum, so that the growung young plats are not smothered by the weds.

At least two weed carried out during the first six months after planting of cutting, once after two months planting band again after an interval of 2 to 3 months.

The weeding operation should be thorough and the soil should be dug deep to eliminate the weeds with roots. This deep digging carried out part of the weeding operation and results in necessary loosing of the soil and stimulation to the plants grow vigorously.

The special care taken to reduce weed growth as much as possible in the first year of planting. Thereafter the shade effect of the fully-grown mulberry will tend to keep the weeds down. Similar, periodical inter-cultivation carried out to particular in the case of dry mulberry cultivation during the first year so that soil loosing results in better aeration and stimulation of plant growth.This also helps in catching the rainwater and it deep penetration for bettr retention of soil moisture.

7.4 Tarining and Pruining of mulberry plants

Inorder to get good leaf yield for 15-20 years, it is necessary to give agood and sturdy frame to the plant. After the planting, the saplings need to be cut at 10-15cm above the ground level within aweek. After the growth period of six monthss, the plants are to be cut at aheight of 25cm above the ground level keeping 3-4strong branches.

In leaf picking method, the first bottom pruning has to be taken up at aheight of 20-25cm height from ground level. After wards , in leaf harvest method, the middle pruning at aheight of 60-70cm has to be followed once in ayear during jan-feb and in shoot harvesting method, each shoot harvest is done at 25cm height which it self acts as pruning.

7.5 Manuring and fertilizer of mulberry plants

Application of abasl dose of organic manure like compost or cattle manure is necessary for the successful establishment of the garden. There after , the young growing plants shuld be assisted to put forth vigorous and maximum growth througgh periodical fertilizer applications.

FYM has to be applied at 20t/ha/year in two doses following the first bottom pruning and third pruning. Fertilizres have to be applied a the recommended schudule and secondary and micronutrients have to be applied wher ever necessary. Foliar spraye such as boron (1%) urea (0.5%), zinc sulphate (01%), etc. will improve the leaf quality. The recommended fertilizer dose (kg/ha) is indicated below.

		N	P	K
Rainfed mulbery				
	1st year	50	25	25
	II year on wards	100	50	50
Irrigated mulberry				
Shoot havest	1st year	100	50	50
	II year on wards	300	120	120
Leaf havest	1st year	100	50	50
	II year on wards	300	120	120

7.8 Managing Irrigation requirment for mulberry plantation

Among the varius inputs, irrigation ranks high in giving quick and good results. Regular irrigation at an interval of 8-10 days is ideal. Usually, 1.5 to a2 acre inch of water per irrigation is enough. It may be noted that there is only one irrigation channel for every two rowa of mulberry plants.

This helps in both saving and more effective use of irrigation water. In the case of water of watr scarcity, drip irrigation can be adopted for better production.

Self-Check-7	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Fill the blank space

1. Write the corrective method used acidic soil below five PH for mulberry plantation (3%)

_____

2. Write the corrective method used alkaline soils for mulberry plantation (3%)

_____

3. Write the the ideal annual rain fall requirment and tempareture of mulberrty plant (2%)

_____

_____

4. Write the mulberry plantation managements factors (4%)

_____

_____

_____

_____

Answer the following question!

Note: **Satisfactory rating 7 and 12 points Unsatisfactory 7 below and 12 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: _____ Date: _____ Score = _____

Short Answer Question

Information Sheet 8: Assessing castor varieties

8.1 Introduction

A lot many varieties of the castor bean plant are used for their flowers, fruits, leaves or for castor oil. A few common ones are selected and explained here. They are listed below.

8.2 Types of Castor Bean Flowers

1. Carmencita Bright Red

This variety is characterized by red stems and bright red 1 inch seed pods.

- The leaves are bronzish red in color or a very deep purplish color
- The foliage color is bright green
- This cultivar can grow up to a height of 5 to 6 feet and is rather spiny
- The germination time for this variety is14 to 21 weeks
- Ideally, these plants should be spaced 48 to 60 inches apart.

The seeds of this plant are poisonous and should be kept away from the reach of children. It is mainly used as a bedding or pot plant. It needs an ideal amount of sun to grow and blooms in the months between June and September

The hardiness zones for this cultivar are 1-13 S/W. Gardeners make use of this owing to the fact that it is a fast growing plant and can turn up the heat in tepid perennial borders. In perennial zones 9 and 10, these plants can grow much taller.

Figure 13: Ricinus 'Carmencita Bright Red'

2. Carmencita Pink

- This cultivar has pinkish red panicles and seed pods.
- Well drained soil with approximately 30 % clay is ideal for the growth of this variety.
- It grows well at a temperature of 12 to 15 degrees centigrade and temperatures below 10 degrees centigrade can only be tolerated for a very short while.
- A lot of balanced fertilizer needs to be used for healthy growth of this plant.
- High sun exposure ensures best growth
- the crop time is around 9 to 10 weeks.

The poisonous seeds should be kept away from children. It is a half hardy plant that can grow up to a height of 90 centimeters. It can be used best as a solitary plant for borders or containers, as a medical plant, an oil plant or an ornamental leaf plant.

Figure 14: Carmencita Pink

3. Carmencita Rose

This is characterized by bluish green foliage and seed pods that are in different shades of peach. This plant is relatively miniature and the blooms flush throughout the season. The USDA zones are 6b through 9b.

This plant is very vigorous and is equally poisonous as the rest and hence should be kept away from the reach of small children. It was bred first in 1954 in Spain by Cebria Camprubi Nadal.

Figure 15: Carmencita Rose

4. Gibsonii

- This plant can grow up to a height of 4 to 5 feet and has pink colored seed pods with leaves that are in dark red shades.
- The USDA zones are 5 to 11 for this cultivar and the blooming season is late summer to early fall.
- For this spiny plant, full sun is ideal for healthy growth
- Well drained soil with a pH of 5.8 to 7.0 is best for this plant.
- The seeds for this cultivar should be planted 0.25 inches deep and should be spaced out 36 to 46 inches so that they have enough space for growing.

The seeds of this variety are highly poisonous and should be kept out of reach of children in order to avoid hazards of any sort. The average germination period is a week or two weeks at a temperature of 65 to 70 degrees Fahrenheit.

This plant can really add an exotic feel to the landscape. Fertilizing is needed every one month for the healthy growth of this variety.

Figure 16: Gibsonii

5. Impala

- This cultivar is relatively more compact and can grow up to a height of 4 feet only.
- The leaves and stems of this variety are reddish brown in color.
- This variety is native to Africa and is perennial in USDA zones 8 to 11.

The flowers are usually creamy yellow that have spiky scarlet husks with brown seeds.

- Full sun exposure ideal for its growth and this one blooms in the summer
- It is deer resistant, heat tolerant and drought tolerant.
- These plants can also be extremely toxic and a few people can also get contact dermatitis upon touching it.
- The average germination period for this cultivar is 7 to 14 days at a temperature of 70 degrees Fahrenheit
- Late summer to early fall is the bloom season for this plant.
- Well amended soil is ideal for the growth of this variety, with a pH of 5.8 to 7
- They should be planted 0.25 inches deep and 1 to 2 seeds per plant for the best growth.
- The seeds are poisonous and care should be taken of the fact that they are not eaten.

- This plant has one of the fastest growth rates.
- These are very architectural and can be used at the back of large borders or island beds.

Figure 17: Impala

6. New Zealand Purple

- The branches lesser than the other varieties and has leaves that are smaller and reddish purple in color
- Fast growing cultivar has hardiness zones 9 to 11 and is annual in the other zones.
- Apart from that, full sun ideal for the growth of this plant, along with dry and sandy soil.
- The color of the foliage is very striking
- Cultivar can reach a height of 10 feet in a single growing season
- Care should be taken around children and pets, since the seeds are highly poisonous
- The seeds take 12 to 14 weeks to bloom
- plant has a glossy texture and resistant to deer.

Figure 18: New Zealand Purple

7. Red Spire

This cultivar can grow up to a height of 7 to 10 feet. It has red stems and red seed pods with leaves that almost look like they are bronze colored. The flowers are red in color and the flowering time for this plant is summer, early fall or late fall. It prefers mesic water and the flowers and fruit are showy. It attracts bees and butterflies and resistant to deer and rabbit

The leaves, roots, fruit, seeds and all other plants are toxic and should be kept away from the reach of small children. Full sun or partial shade is ideal for the growth of this cultivar. At cultivation time, these should be spaced 36 to 48 inches apart for healthy growth. The USDA hardiness zones are 9a, 9b, 10a, 10b and 11. This plant is drought tolerant and has average water needs. Over watering this plant can spoil it completely.

Figure 19: Red Spire

8. Sanguineus

- This one has blood-red stems and silvery leaves
- Full sun or partial shade is ideal for the growth of this plant
- This cultivar can attract a lot of bees and butterflies
- It is deer and rabbit resistant and all parts of this plant are highly poisonous.
- For cultivation of this plant, the seeds should be self fertile and soaked for 24 hours before sowing them
- cultivar can grow up to a height of 40 feet and is hardy in zones 8 to 11
- It repels mosquitoes and other biting insects.
- It has average water needs and over watering causes the plant to wither.
- At the time of cultivation, these need to be spaced 36 to 46 inches apart
- In the initial stages, this plant grows straight up and develops branches only later on.

Figure 20: Sanguineus

9. Zanzibarensis

- This cultivar is another tall variety that is 7 to 10 feet in height and has green leaves with white midribs.
- It is an annual plant that can give a tropical look to any landscape and grows very fast.
- Care should be taken about the fact that its growth is not restricted otherwise the roots can get cramped and that can leave the plant stunted.

- All parts of this plant are poisonous and hence should be kept away from the reach of children and pets
- The seed heads of these plants exist in various colors.
- Full or partial sun is ideal for the growth of this plant.
- The planting method for the best growth of this plant is direct seeding.
- Ideally, these should be started indoors.
- For this plant to grow tall,
- it is necessary that it planted in very rich and fertile.
- Typically, the seeds of this cultivar take 12 to 14 weeks to bloom.

Castor Bean plants are very useful plants due to the various amounts of uses that they have. However, they should be handled with a lot of care due to the fact that they are highly poisonous.

Figure 21: Zanzibarensis

Self-Check-8	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Fill the blank space

1. Write the nine types of castor bean (9%)

_____,_____

_____,_____

_____,_____

_____,_____

_____,_____

Answer the following question!

Note: **Satisfactory rating 5 and 9 points** **Unsatisfactory 5 below and 9 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: _____ Date: _____ Score = _____

Short Answer Question

Information Sheet 9: Identifying the morphology of castor

9.1 morphology of castor plant

The castor plant is a robust annual that may grow 6 to 15 feet (2-5 meters) in one season with full sunlight, heat and adequate moisture. In areas with mild, frost-free winters it may live for many years and become quite woody and tree

The large, palmately lobed leaves may be over 20 inches (50 cm) across and resemble a tropical aralia.

There are several cultivated varieties with strikingly different foliage colorations are:

- Black-purplish
- Dark red-metallic
- Bronze-green
- maroon
- Bright green with white veins
- Just plain green

Castor plant grows very rapidly with little care or insect pests and produces a mass of lush tropical foliage, its use in cultivation should be discouraged because of the extremely poisonous seeds or "beans." This is particularly true where small children might be attracted to the large, beautifully-mottled seeds which are produced in prodigious numbers.

This evergreen herbaceous can grow up to a height of 40 feet, developing wood like stems in climates that are free of any frost. It is a perennial plant that is very robust and can easily be grown in warm and temperate climates. It usually does not grow more than 6 to 10 feet in one growing season. In the initial stages, it grows straight up and develops branches later on to form a well-proportioned small tree with strong stems and a dense canopy. If the temperature falls below 32 degrees Fahrenheit, this plant dies. Additionally, this plant does not have a milky latex sap. Instead, it has a watery sap.

9.2 Leaves of castor

- The leaves of this plant are star-shaped and are on long petioles
- Grow above 2.5 feet across
- Every leaf has around 5 to 11 deeply incised lobes with very prominent central veins
- The leaves of this plant are glossy green in color but some species have blackish purple, deep red metallic, maroon, or bronzish green leaves with white veins.
- Flowers of this plant are produced on the stems at heights of 8 to 18 inches
- The flowers are not showy and do not have petals
- The male flowers of this plant are produced below the female flowers
- The flowers of this plant usually do not have petals and are not showy either.

Figure 22: Castor plant

Castor bean plant showing large, tropical, palmately-lobed leaf and cluster of spiny red fruits. On some plants the fruits are green.

9.3 Castor Bean Flowers and Fruits

Flowers occur most of the year in dense terminal clusters (inflorescences), with female flowers just above the male flowers. This species clearly monoecious, with separate male and female flowers on the same individual. There are no petals and each female flower consists of a little spiny ovary (which develops into the fruit or seed capsule), and a bright red structure with feathery branches (stigma lobes) that receives pollen from male flowers.

Each male flower consists of a cluster of many stamens which literally smoke as they shed pollen in a gust of wind.

Flower cluster (inflorescence) of castor bean (**Ricinus communis**).

- The upper spiny balls (ovaries) with red, star-shaped stigmas are the female flowers.
- The lower male buds open into whitish-yellow clusters of stamens
- The wind-pollinated flowers have no petals
- The shiny seeds of castor plants are a little larger than pinto beans and have very beautiful and intricate designs.
- At one end is a small, spongy structure called the caruncle, which aids in the absorption of water when the seeds are planted.
- \Like human faces, finger prints or the spots on a leopard, no two seeds have exactly the same pattern.
- They are unquestionably among the most deadly seeds on earth
- irresistible appearance that makes them so dangerous.

Figure 23: Castor Bean Flowers & Fruits

9.4 Castor seed

The many "faces" of castor seeds. Like the faces and fingerprints of people

- The beautiful designs on castor seeds exhibit infinite genetic variation

- The small structure on the end of each seed is a caruncle
- The seeds superficially resemble the bodies of ticks, particularly ticks engorged with blood.

Figure 24: castor seeds

9.5 Castor cultivation

- Castor propagated through sexual method only.
- Seeds are directly sown in the field for raising the plantation.
- Castor grows all types of soils like
  - ✓ Red,
  - ✓ Sandy loam
  - ✓ Light alluvial soils
- It grows vigorously in soil having maximum organic matter.
- It cannot withstand water logged contrition, so well drainage system maintain in the plantation.
- Non-bloomy red variety of castor (NBR-1) is suitable for eri rearing.
- The ideal season for planting of castor from March-April and September-November.
- 1x1 m spacing is recommended for systematic.
- Around 4800 kg leaf can harvested in a year from one acre plantation.

9.6 Uses of Castor Bean Plants

There are quite many uses of the castor plant. The most prominent ones are listed below

- It is used for theproduction of castor oil.
- Ripe seeds that have their hull or outer cover removed can be pressed to extract castor oil.
- Castor oil is used all over the world for so many different purposes.
- It is used as a purgative for constipation, to promote hair growth and to help pregnant women.
- Skin disorders like boils and inflammations can also be cured using castor oil.
- A lot of people also use castor oil as a cure for abdominal pain.
- zIt is the most widely used in India.

Castor bean seeds without the outer cover removed can be used for birth control, constipation, leprosy, and syphilis.

In the manufacturing industry, castor bean seed capsules are used to make paint, lubricating oils and varnishes.

Figure 25: Costor seed product

Self-Check-9	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Fill the blank space

1. Write the cultivated varieties castor plant with strikingly different foliage colorations (5%)

_____,_____

_____,_____

_____,_____

2. write the leaf color of castor bean species(5%)

_____,_____

_____,_____

_____,_____

3. Write the types of soil castor plant perfer to growth.(3%)

_____,_____

_____

Answer the following question!

Note: **Satisfactory rating 7 and 13 points** **Unsatisfactory 7 below and 13 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: _____ Date: _____ Score = _____

Short Answer Question

Information Sheet 10: Identifying castor plantation requirements

10.1 Soil requirement for castor cultivation

Castor cultivated on:

- Lands not suitable for commercial farming
- come up well in soil that are not fertile and having less annual rain fall
- Seeds grown on wide range of soils which are fairly deep and well drained
- The most suitable soils for castor cultivation are:
  - ✓ Deep
  - ✓ Moderately fertile, with slightly acidic conditions
  - ✓ Well drained sandy loam soils
  - ✓ The ideal soil PH of soils should be around 6.0 for better yield
  - ✓ cultivated on soils with PH range of 5.0 to 8.5

10.2 Castor plantation procedure

A. Seedbed Preparation:

To prepare the seedbed

- Plow or disk the land
- Be sure the soil is moist at the planting depth of one to three in.

B. Seeding Date

Castor beans planted in early May, about the same time as corn. Seedlings will emerge in 10 to 21 days.

C. Method and Rate of Seeding:

Good stands of castor beans require heavy planting rates, because germination of the seed is usually rather low. Seeding at 10 to 14 lb/acre will give a good stand, depending on the seed size and the height of the variety.

Row width should be 38 to 40 in. with 8 to 12 in. between plants. Because of differences in germination rates and plant size, growers should calculate rates based on the seed lot. Seeds planted at a depth of 12 to 3 in.

Castor beans are oily and easily broken; they can clog machinery and cause irregular spacing. Most corn planters with an air metering system should perform well. Planters using metering plates will require plates with proper cell size. Always check the planting unit to ensure that excessive bean cracking or crushing is not occurring during planting.

Figure 26: Castor seeds

D. Fertility and lime requirements:

Castor beans grow well on slightly alkaline or acid soils. The most important factor in fertility level is the supply of nitrogen in the soil. Insufficient nitrogen results in reduced castor bean yields. Excessive nitrogen produces heavy vegetative growth with little or no increase in seed yield

The amount of nitrogen required by castor beans depends on the soil organic matter content as shown in Table 1. Preplans and side dress applications of nitrogen may be beneficial at the higher application rates or on lighter-textured soils.

Nitrogen recommendations for castor beans	
Soil Organic Matter	Nitrogen Application Rate
-- % --	-- lb/acre
< 2	100
2 - 4.9	80
5 – 10	60
> 10	40

In general, castor beans require the same amount of nutrients as other low demand field crops. For typical silt loam soils, testing in the optimum range (6 to 10 ppm P; 81 to 100 ppm K), approximately 20 lb P_2O_5 and 40 lb K_2O applied per acre.

If soil tests are below optimum, approximately 5 lbs P_2O_5 and 20 to 30 lb K_2O applied in addition to the previous amounts. Castor beans do not generally respond to phosphorus, and excess soil phosphorus levels can actually decrease yields. Therefore, do not apply P_2O_5 except where soils test in the optimum or below optimum level for extractable P.

E. Variety Selection:

Castor bean varieties developed to produce large yields of seed with a single harvest. The tall varieties may reach a height of 10 feet or more. The dwarf types seldom exceed four or five feet

No information is available about the adaptability of varieties to the upper Midwest

The seeds egg-shaped, oblong, or round, usually with an enlargement on one end, called the caruncle. Seeds vary in size, but most commercial varieties average 1,000 to 1,500 seeds/lb.

F Growth Habits:

In the tropics, the castor bean plant is a perennial. It grown as an annual in temperate regions, however, requiring a growing season of 140 to 180 days.

Germination is slow. Seedlings will emerge 10 to 21 days after planting. Commercial varieties grow to a height of 3 to 10 ft.

The plant consists of several stems or branches, each terminated by a spike. The mature spike is six to 12 in. long. In some varieties, female flowers are on the upper part of the spike and male flowers on the lower part. Other varieties have male and female flowers interspersed on the spike. Varieties with spikes of only female flowers have made possible the production of hybrid seed. Male flowers drop off the spike after pollination.

The lower spikes on the plant mature first, followed by the upper spikes. Each spike bears 15 to 80 capsules, which may be prickly or smooth on the outer surface. The capsules, which develop from the female flowers, contain three seeds each and explode when ripe.

The plant is not a legume, as its name would imply. It has no soil-improving value other than that of any rotation crop

10.3 Castor bean uses

Castor (Ricinus communis L.) grown for its seeds. The oil extracted from castor seed used widely for various purposes like:

- Used as lubricant in high speeds engines
- aero planes
- In the manufacture of soaps
- Transparent paper
- printing inks
- Varnishes
- Linoleum and plasticizers
- Used for medical and lighting purposes
- Used to make manure and plant stalks as fuel or as thatching material or for preparing pulp
- Castor leaves fed to silkworms

Figure 27: Castor leaf used to fed silkworm

Self-Check-10	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Fill the blank space

1. Write the Castor plantation procedure (6%)

_____

_____

_____

_____

_____

2 List down the use of castore bean product (5%)

_____,_____

_____,_____

_____,_____

_____,_____

_____,_____

Answer the following question!

Note: **Satisfactory rating 6 and 11 points** **Unsatisfactory 6 below and 11 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: _____ Date: _____ Score = _____

Short Answer Question

Information Sheet 11: Carry out castor plantation activities

11.1 Preparation of the field

Plough two-three times with country or mold board plough.

11.2. Application of organic manures

Spread 12.5 t/ha of FYM (farmyard manure) or compost evenly on the main field before last ploughing and incorporate in to soil by working a country plough

Apply 30 kg Sulphur/ ha through gypsum at the time of last ploughing for higher castor yield.

NOTE: Do not leave FYM or compost exposed to sunlight, as nutrients will be lost.

11.3. Identify Seed rate

Adopt a seed rate of 10 kg/ha for varieties and 5 kg/ha for hybrid.

11.4. Identify Spacing

Adopt the following spacing.

	Rainfed situation	Irrigated situation
Varieties	90 cm x 60 cm	90 cm x 90 cm
Hybrids	120 cm x 90 cm	150 cm x 120 cm

- In irrigated conditions for clay soils wider spacing of 150 x 150 cm adopted.
- For TMV 5 short duration variety, 60 x 30 cm adopted.

11.5. Application of fertilizers

- Apply NPK fertilizers basally as per soil test recommendations as far as possible.
- If soil test recommendations are not available, follow the blanket recommendation as follows

	Recommended NPK kg/ ha
Rain fed conditions	
Varieties	45 : 15 : 15 NPK kg / ha
Hybrids	60 : 30 : 30 NPK kg / ha
Irrigated condition	
Varieties	60 : 30 : 30 NPK kg / ha
Hybrids	90 : 45 : 45 NPK kg / ha

In rain, fed situations apply 100% P & 50% N&K basally & remaining quantity applied in one or two top dressings based on the soil moisture availability.

In irrigated situations, apply 100% P & 50% N&K as basal & remaining quantity N&K applied in two equal splits at 30th & 60th DAS.

Apply 12.5 kg ZnSO4 ha-1 (if the soil available Zn is < 1.2 ppm) and 25 kg FeSO 4 ha-1 (if the soil available Fe is < 3.7 ppm for non-calcareous soil and < 6.3 ppm for calcareous soil)

11.6. Pretreatment of seeds

- Treat the seeds with Carbendazim at 2 g/kg of seed.
- Soak the seeds in water for 20 hours.
- In rain fed situations, seed priming with 1% KCl for 3 hours and sowing a week before onset of monsoon recommended.

11.7. Sowing

- Sow the seeds adopting the recommended spacing.
- Place the seeds at depth 4 - 6 cm.
- Put one seed in each hole.
- Gap filling
- Gap fill on the 15th day of sowing and simultaneously thinning done leaving one healthy plant.

Self-Check-11	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Fill the blank space

1. Write the procedure of castor plantation activities (7%)

_____,_____

_____,_____

_____,_____

2. Write the castor bean sowing procedures (4%).

_____

_____

_____

_____

_____

Answer the following question!

Note: **Satisfactory rating 6 and 11 points** **Unsatisfactory 6 below and 11 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: _____ Date: _____ Score = _____

Short Answer

Information Sheet 12: Implementing castor plantation managements

12.1 Weed management

Apply pre emergence herbicide Pendimethalin at three lit/ha or Fluchloralin at two lit/ha on three DAS followed by hand weeding twice on 20th and 40th DAS.

A. Weed Control:

The slow emergence and early growth of castor beans means the plants are not strong competitors against weeds. Rotary hoeing during the first few weeks after planting, followed by row cultivation should provide acceptable control. Because the main lateral roots of the castor bean plant are near the soil surface, cultivation shallow.

B. Intercropping

Raise one row of castor for every six rows of groundnut. In the case of late receipt of monsoon black gram + castor at 6:1 ratio recommended

Intercropping of castor with Black gram or Green gram in 1:2 ratio recommended for rained situation. Intercropping of castor with onion in 1:2 ratio by adopting 1.5 m x 1.0 m spacing recommended for irrigated situation.

12.2 Diseases and their Control:

Resistance to various diseases varies among castor bean varieties. During periods of heavy rains or dews, capsule molds, Alter aria leaf spot and bacterial leaf spot may occur. Alter aria leaf spot is more severe in nitrogen-starved plants. Other diseases may occur, particularly in wet seasons

To prevent disease problems

- Rotation planting program
- Treatment of seed with a fungicide prior to planting recommended
- Thrum is the only registered seed treatment fungicide.

12.3. Insects and predators control:

Though leaf- and stem-feeding insects usually do not cause serious damage to castor bean plants, cutworms and wireworms may reduce stands. Stinkbugs, corn earworms, webworms, caterpillars, grasshoppers, trips, spider mites, leaf miners, Lingus bugs, the yellow-striped armyworm, and the European corn borer also may attack the plants.

12.4. Harvesting matured crop for next production

- Observe the crop considering the average duration of the variety.
- One or more capsules show sign of drying.
- Cut the matured racemes without damaging the secondaries.
- Dry the capsule in the sun without heaping it in the shade.
- Use castor Sheller to separate the seeds or beat the dried capsule with wooden planks, winnow and collect the seeds.

Self-Check-12	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Fill the blank space

1. Write the procedure of castor plant disease problems methods (4%)

_____

_____

_____

2. Write the castor plant weeds management methods (3%)

_____

_____

Answer the following question!

Note: **Satisfactory rating 4 and 7 points Unsatisfactory 4 below and 7 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = _____

Name: _____ **Date:** _____

Short Answer

L #74	LO #2 Monitor silkworm seed techniques, morphology and physiology of silkworm

Instruction sheet

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- **Implementing grain age seed production and identifying Hibernation**
- **Carrying out acid treatment**
- **Studying the life cycle of silkworms**
- **Carrying out comparative implementation of mulberry and non-mulberry silkworms**
- **Identifying digestive, excretory, reproductive, & respiratory system**

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Implement grain age seed production and identifying Hibernation
- Carry out acid treatment
- Study the life cycle of silkworms
- Carry out ccomparative implementation of mulberry and non-mulberry silkworms
- Identify digestive, excretory, reproductive, & respiratory system

Learning Instructions:

Read the specific objectives of this Learning Guide.

1. Follow the instructions described below.
2. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them
3. Accomplish the “Self-checks” which are placed following all information sheets.
4. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks)
5. If you earned a satisfactory evaluation proceed to “Operation sheets
6. Perform “the Learning activity performance test” which is placed following “Operation sheets”
7. If your performance is satisfactory proceed to the next learning guide,
8. If your performance is unsatisfactory, see your trainer for further instructions or go back to “Operation sheets”.

Information Sheet 1: Implementing grain age seed production and identifying Hibernation

1.1 Introduction

Silkworm eggs are very important basic material for the production of silk.

Good quality seed defined as:

- Free from diseases
- Has more number of good egg
- Gives uniform hatching
- Assures a stable cocoon crop.

Egg (Polu koni) is the backbone of silk industry. Healthy egg production indeed the primary requisite for conducive growth of the entire silk industry. Timely supply of superior quality of silkworm seed can alone sustain sericulture as a commercial crop in competition with other cash crops.

A key factor for success of Sericulture industry is not only augmentation of silkworm food plants but also timely supply of superior quality of silkworm seed to the farmers ensured.

The quality of silkworm seed defined as to the one where the laying are entirely free from diseases, has more noose viable eggs, gives uniform hatching and assures a stable crop.

To produce good quality eggs there must be a sound seed organization with proper elite seed multiplication network to produce large quantities of quality commercial seed.
Silkworm seeds produced in the grain age and therefore grain age is the first and the most important aspect, which needs special attention.

Success of silkworm rearing largely depends on careful grain age operation. Systematic and methodological drainage not only minimize larval morality due to diseases but also results in vigorous progenies.

The drainage operations consist of

- Selection
- Storage
- Preservation of seed cocoons.

The muga raw silk production has not shown significant growth. The fundamental reason behind the poor production are:

- Shortage of quality muga seed (eggs) for commercial rearing
- Non- availability of quality seed required quantity and in the proper season
- For conducting, the commercial crop rearing attributed major factor for decline of muga silk production
- Unlike in mulberry sericulture, the seed transacted in the form of seed cocoon in muga silk industry

1.2 Silkworm seed production

Silkworm eggs are very important basic material for the production of silk. The State Departments of Sericulture (DOS), National **Silkworm Seed** Organization (NSSO) of Central **Silk** Board and private Licensed **Seed** Producers (LSP) are the agencies involved in the commercial **silkworm seed production**

A. Grain age sericulture

Grain ages are temperature-controlled facilities where cocoons kept under controlled temperature conditions until the pupa emerges from them as moths after about a week. The Bombyx mori moth is the key player in the making of silk production. Cultivation of mulberry leaves and rearing of **silkworms** go hand in hand.

B. Disinfection of Grain age

Implements Disinfection means killing the pathogens in the grain age building and appliances.

I. A day before grain age sericulture

- The rooms and appliances to washed with 5% bleaching powder solution
- Sun dried for 3-4 hours

II. A day after Grain age sericulture

- The rooms and appliances should properly disinfected with a mixture of 2% formalin, 0.5 - 1% lime and 0.5% detergent solutions
- Kept closed for 24 hours
- Room should disinfected at the rate of 2.5 liters per square meter floor area

Steps silkworm seed production

Step 1. Procurement of seed cocoons in the seed market

In the cocoons market, the grain age authorities will purchase the required quality of multivoltine cocoons in an open auction.

Figure 28: Purchasing cocoon

Step2. Preliminary examination/ selection and sorting of seed cocoons

Investigations at three stages:

1. Pupa test
2. Forced exclusion test
3. First day moth examination.

Step3. Preservation of seed cocoons

The cocoons preserved in single layer well ventilated rooms under natural light and dark conditions

Step4. Sex Separation at pupal and moth stage

Identification of male and female pupae

Male Pupae	Female pupae
1. Smaller in size	Larger in size
2. Narrow pointed abdomen	2. Broad abdomen
3. Small dot like mark on the ventral side near the top demarcation line of 9 abdominal segment.	3. X mark seen on the ventral side of 8th abdominal segment

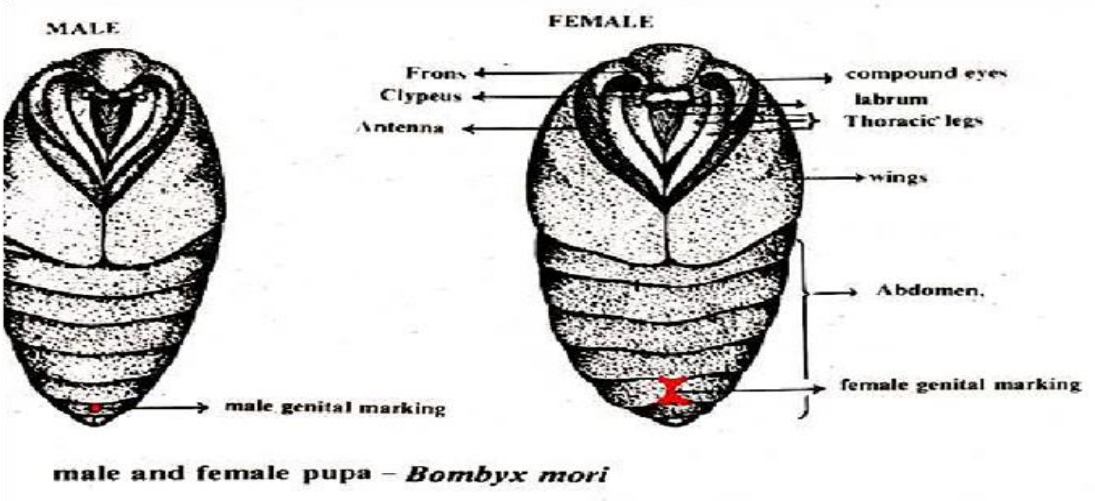


Figure 29: Male and female pupae

Step5 Identification of male and female moths

Male months	Female months
1. More active	1. Less active
2. Smaller in size	2. Larger in size
3. Bigger antennae	3. Smaller antennae
4. The caudal end has a pair of hooks known as harpes helping in copulation	4. The caudal end has a median knob like projection with sensory hairs which is protruded & retracted to expel the pheromones (Ovipositor)

Figure 30: Female & male moths

Figure 31: Abdominal end of female & male moths

Step6. Synchronization

Step7. Coupling and decoupling

Step8. Ovipositional

1.3 Preservation and Handling of hibernated eggs

In univoltine and bivoltine races, the eggs enter into diapauses in 40-50 hours after ovipositional at 25 ºC. Eggs when laid yellow in color gradually they turn brown and then purplish brown. Such eggs do not hatch unless they activated by cold temperature. This naturally achieved in temperate areas

In tropical countries, the winter condition stimulated by preserving the eggs at required temperature in a cold storage. Such cold storage of eggs carried out by following specific schedules. Low temperature preservation terminates the diapauses and activates the eggs to hatch.

The schedule comprises three distinct phases

- Storing at 25 ºC
- Cold storage at 5ºC
- Intermediate phase, where the temperature is gradually lowered from 25ºC to 5ºC.

Silkworm eggs preservation of methods include:

A. Short-term refrigeration for 3 months

The eggs are kept at 25ºC for 3 days and then cold storage for 90 days at 5ºC. The cold storage and release of eggs should be through an intermediate temperature of 15ºC for 6-12 hours.

B. Refrigeration for 4 and 6 months

The preservation period at different temperature given below

Hibernation Period	Temperature							
	25ºC	20ºC	15ºC	10ºC	5ºC	2.5ºC	5ºC	15ºC
4 Months	10 days	2 days	2 days	3 days	50days	50days	-	1 day
6 Months	20 days	15 days	10 days	10 days	50 days	60 days	5 days	2-3 days

The eggs stored according to the above released 15 days earlier or later than the scheduled period, without affecting the hatching. After releasing the eggs from 2.5ºC, the eggs must be kept at an intermediate temperature of 15ºC for one day and
Then transferred to incubation room.

C. Long term refrigeration (10 months):

The schedule for preserving the eggs for 10 months given in the following table

Hibernation Period		Temperature								
	25ºC	23ºC	20ºC	15ºC	10ºC	5ºC	2.5 C	15ºC	2.5ºC	15ºC
10 Months	40 days	20 days	30 days	25 days	25 days	60 days	50 days	3days	30 day	2-3 days

Self-Check-1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Fill the blank space

1. _____very important basic material for the production of silk (2%)

2. Write the definition of quality of silkworm seed (4%)

_____,_____

_____,_____

3. Mention the consist drainage operations of silkworm seed (3%)

_____,_____

_____

4. Write the of Steps silkworm seed production (5%)

_____,_____

_____,_____

_____,_____

_____,_____

5. Write the methods silkworm eggs preservation (3%)

_____,_____

_____,_____

Answer the following question!

Note: **Satisfactory rating 9 and 17 points Unsatisfactory 9 below and 17 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: _____ **Date:** _____ Score = _____

Short Answer

Information Sheet 2: Carrying out acid treatment

2.1 Introduction

The artificial hibernation and the treatment with hydrochloric acid after refrigeration of the bivoltine silkworm eggs, Bombyx mori were compared to evaluate the quality and productivity of cocoons in the tropical conditions, where both types of silkworm eggs are available all the year round.

2.2 Acid Treatment of Bivoltine Eggs.

Multivoltine breeds never undergo diapauses, but univoltine and bivoltines strains undergo diapauses or hibernation. Therefore, to check the diapauses and to rear the worms in case of univoltine and bivoltine races.

In bivoltines, to terminate the diapause the eggs are:

- Treated with HCl to get hatching in about 10 days
- In case of sheet eggs, the egg sheets should dipped in 2% Formalin for 10 minutes for surface sterilization
- Increase adherence of eggs to sheets
- Commercial grade of HCl available is of 1.15-1.18 specific gravity
- Prepare the required specific gravity acid by adding water
- Correct age of acid treatment is 20-24 hours after ovipositional

In common acid treatment or hot acid treatment, the eggs treated with hydrochloric acid of 1.072 specific gravity at 46.1°C for a dipping duration of 5-5½ minutes. After treatment, wash the egg sheets/loose eggs thoroughly in running water for 30-35 minutes to remove all the acid traces and then dry the eggs. (Kamble, 2004)

Artificial hatching done by two methods.

1. Cold Treatment/ Physical methods

In this method, e.g. Cold Treatment/ Physical methods allowed to complete the hibernation period under cold conditions

2. Chemical Method / Acid Treatment

Treatment cold or hot acid treatment of these two methods, hot acid treatment more popular

Hot acid treatment purposes

- This treatment practiced just between 15-20 hrs of ovipositional
- The egg diapason characteristics treated.
- When the treatment postponed the eggs preserved at 5ºC 20th hour.

The period of cold storage within 5 days. During this period

- Eggs taken at any time for acid treatment, but before the treatment, eggs are exposed to 25-26ºC for 2-3 hours
- Hydrochloric acid of specific gravity 1.075 (15%) heated to a temperature of 46.1º
- The silkworm eggs immersed in the acid for 5-6 min
- The specific gravity as measured at 15ºC
- Then wash the eggs in running water to remove traces of acid and dry under shade. “Now the eggs are ready for Incubation”

Self-Check-2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Fill the blank space

1. Write the two method artificial hatching (3%)

_____,_____

2. Write the hot acid treatment purposes (3%).

_____

_____

_____

3. Write the uses of bivoltines, eggs to terminate the diapause (5%)

_____,_____

_____,_____

_____,_____

Answer the following question!

Note: **Satisfactory rating 6 and 11 points Unsatisfactory 6 below and 11 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: _____ **Date:** _____ Score = _____

Short Answer

Information Sheet 3: Studying the life cycle of silkworms

3.1 Introduction

A material, which composed of thin and continuous strands known as fiber.

Two of type's fiber

A. Natural fiber

- Type of natural fiber or animal fiber
  - ✓ Examples of natural fibers are cotton and silk

B. **Synthetic fiber**

- ✓ Synthetic fibers are manmade fibers
- ✓ Examples of synthetic fibers nylon, polyester, etc.

3.2 History of silk

Silk discovered around 3500 BC in China. For a long period, silk shipped to other parts of the world through trade. Technological advancement and new developments have enabled manufacturers to produce different types of silk from different silkworms based on luster and texture. Mulberry silk is the most common silk moth that used for producing silk. Rearing of the silkworm known as sericulture.

Figure 32: Silkworm

Figure 33: History of silk

3.3 The life cycle of silkworm

The life cycle of silk moth starts when a female silk moth lays eggs. The caterpillar or larvae hatched from the eggs of the silk moth.

The silkworms feed on mulberry leaves and give rise to pupa. In the pupa stage, a weave netted around by the silkworm to hold itself. After that, it swings its head, spinning a fiber made of a protein and becomes a silk fiber.

Several caterpillars form a protective layer around pupa and this covering known as the cocoon. The silk thread (yarn) obtained from the silk moth's cocoon.

The life cycle stage of silkworm include:

Stage 1: Egg

An egg is the first stage of the life cycle of the silkworm. The egg laid by a female moth, which is mostly the size of small dots. A female moth lays more than 350 eggs at a time. In the springtime, the eggs hatch due to the warmth in the air. This procedure happens once in every year.

Stage 2: Silkworm

A hairy silkworm arises after the eggs crack. In this stage of silkworms, the growth happens. They feed on mulberry leaves and consume a large amount of these leaves for around 30 days before going to the next stage.

Stage 3: Cocoon

In this stage, silkworms spin a protective cocoon around itself. It is the size of a small cotton ball and is made of a single thread of silk.

Stage 4: Pupa

The pupa stage is a motionless stage. In this stage, people kill the pupa by plunging the cocoon into boiling water and unwind the silk thread.

Stage 5: Moth

In this stage, the pupa changes into an adult moth. The female moth lays eggs after mating and thus the life cycle of silkworm begins again.

Stage	Period (days)	Characters
Egg	9-12	Yellowish –whit, semi round, 1mg wt
larvae	25-30	Last instar larvae is greenish, cylindrical caterpillar, 3-3.5 inches long, bears 3 pairs of thoracic legs, 5 pairs of prolog's, last pair modified to claspers, apiracles. 1 thoracic and 8 abdomianal. Each larvea feeds on 90gm of leaves during its larval period (voracious feeders)
I. Instar	3-4	
II. Instar	2-3	
III. Instar	3-4	
IV. Instar	5-6	
V. Instar	7-8	
Pre-pupa pupa	4-7 10-12	Nonfeeding stage, cocoon spinning within 2-4days
Adult	2-3	Robust creamy white month, bipectinate antenna, non-feeder, poor flier. Each female lays 400-600 eggs, secretes alkaline solution to dissolves the cocoon (fibers)

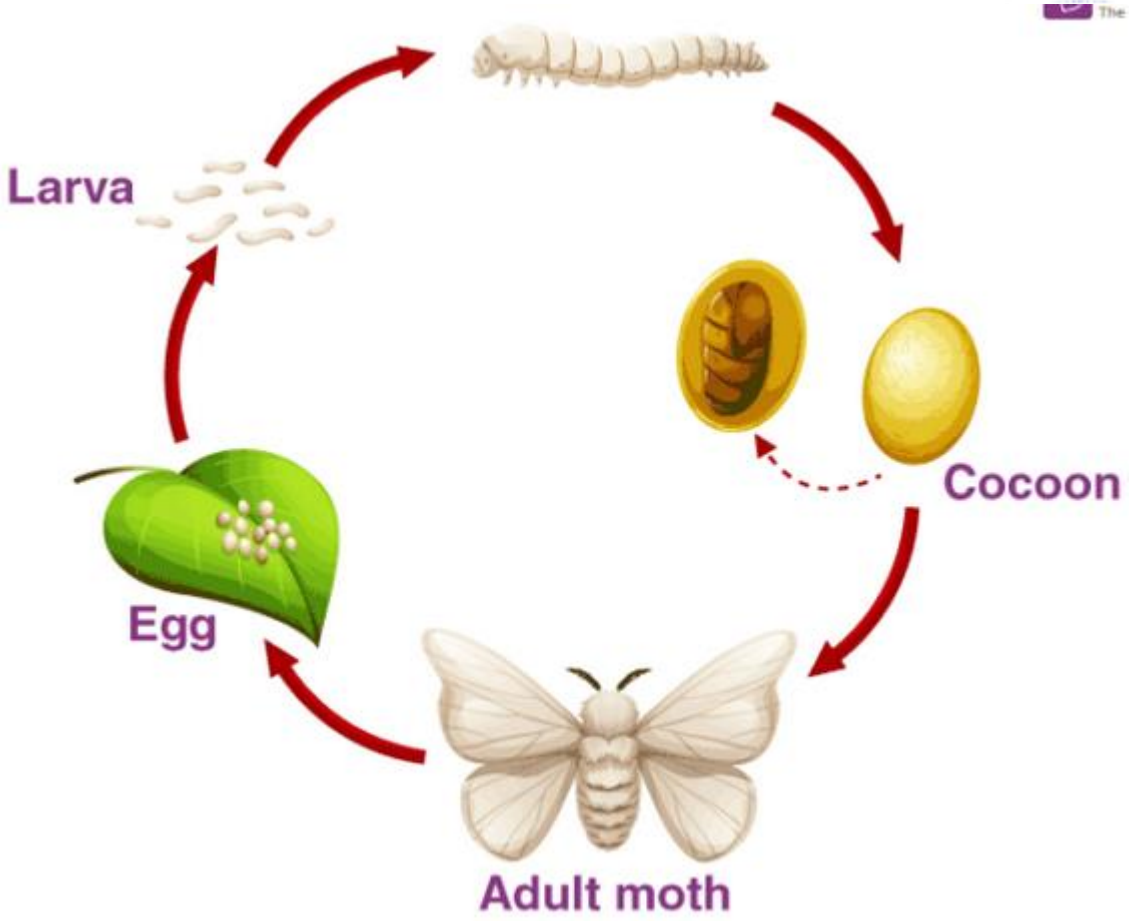

Larva
Cocoon
Egg
Adult moth

Figure 34: Life cycle of silkworm

3.4 Processing of silk

Extracting silk from the cocoon known as the processing of silk. Silk separated from the cocoon by exposing it to sunlight. After the reeling of silk done, the process of unwinding silk from a cocoon takes place. Silk thread then bleached. The silk fiber then spun into silk threads.

Self-Check-3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Fill the blank space

1. Write the two fibers (3%)

_____

_____

2. Write the life cycle of stages of silkworm (5%)

_____,_____

_____,_____

_____

Answer the following question!

Note: **Satisfactory rating 5 and 8 points Unsatisfactory 5 below and 8 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = _____

Information Sheet 4: Carrying out comparative implementation of mulberry and non-mulberry silkworms

4.1 Introduction

Silk is a natural protein in fiber, some form of which woven into textiles.

The best know silk obtained from the cocoons of the larvae of the mulberry silk warm Bombyx mori reared in captivity (sericulture)

4.2 Mulberry silks

- The most common among the many kinds of silk
- Makes up 90% of the silk supply in the world.
- The popular kind produced by the bombyx mori silkworms, which are fed from the mulberry bush (thus the name)

2. Non-mulberry silks

Three other commercially important types fall into the category of non- mulberry silks namely:

- A) Eri silk
- B) Tasar silk
- C). Muga silk.

A. Eri silk

belongs to either of two species namely Samia ricini and Philosamia ricini. P.ricini (also called as castor silkworm) is a domesticated one reared on castor oil plant leaves to produce a white or brick red silk popularly known as Eri silk

B. Tasar silk

The second most produced silk behind mulberry silk. Mulberry silk created by caterpillars that eat mulberry leaves exclusively.

C. Muga silk

Comes from the cocoons of caterpillars that only found in Assam, India. Some caterpillars who produce eri silk raised on the leaves of the castor oil plant

There are also other types of non-mulberry silk, which are mostly wild and exploited in Africa and Asia, are

- Anaphe silk,
- Fagara silk,
- Coan silk,
- Mussel silk
- Spider silk. Despite the many kinds of silk fibers, Silks woven into different weaves/ fabrics.

Silk weaves include:

- Chiffon
- Organza,
- Doupioni
- Pongee
- Faille

Self-Check-4	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Fill the blank space

1. Write the types of silk that dominance the world. (2%)

_____

2. Write the three types of non-mulberry silk (4%)

_____,_____

_____

3. Write the types of Silk weaves (5%)

_____,_____

_____,_____

_____,_____

Answer the following question!

Note: **Satisfactory rating 6 and 11 points Unsatisfactory 6 below and 11 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: _____ **Date:** _____ Score = _____

Short Answer

Information Sheet 5: Identifying digestive, excretory, reproductive and respiratory system

5.1 Anatomy silkworm

Anatomy is a branch of science concerned with the bodily structure as revealed by dissection. In case of silkworm larva, just under the skin at the median line of dorsal surface of the larva there is a dorsal vessel and around them. Many dorsal muscles and fat bodies found.

Inside the abdomen occupied by the alimentary canal. On both the sides of the alimentary canal, there are tracheae. On the ventral side of the alimentary canal, there are silk glands around them many fat bodies found. Under those organs, there are ventral muscles. Along the median line of the ventral side of the body, there is a nerve chord.

The gonad lies on the dorsal side of the fifth abdominal segment, one by one on either side, right and left of the dorsal vessel. Malpighian vessels arise at the junction of the small intestine and colon in the hindgut of the digestive tract. Moreover, there are several endocrine glands are present.

Main organs of the larval body are

- Digestive organ
- Dorsal vessel
- Circulatory organ
- Malpighian tubules
- Respiratory organ
- Nervous system
- Sensory organs
- Reproductive organs
- Fat tissues
- Muscles.

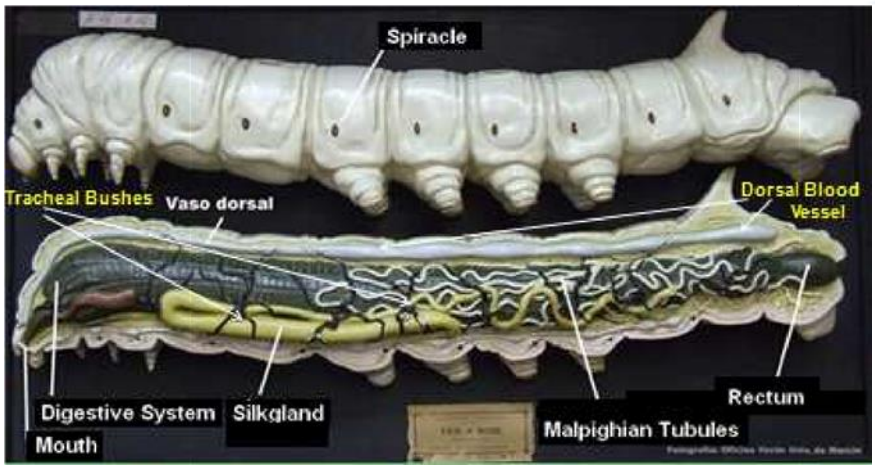


Figure 35: Main organs of larvae body

5.2 Digestive system of silkworm larvae

In the silkworm larva the digestive system is more or less a straight tube from the mouth to the anus divided into three main parts:

- The fore-gut or stomodeum
- Mid-gut or mesenteric
- Hindgut or proctodeal.

The oral aperture opens into the mouth cavity, which followed by a narrow pharynx and esophagus. The esophagus narrow at the anterior end and gradually widens towards the posterior end.

The cardiac or stomodea valve at the end of the foregut that retains the chewed mulberry leaf bits in the esophagus for some time and prevents the regurgitation (backward flow) of food from mid-gut to foregut

The mid-gut a cylindrical tube narrow at the posterior end. Digestion and assimilation of food, take place mainly in the mid-gut. The digestive fluid secreted principally from the goblet cells at the mid-gut epithelium and the cylindrical cells absorb the digested food.

The fore and hindguts have a chitins lining, but an inner layer of per trophic membrane in the mid-gut generally protects the mid-gut epithelium from mechanical damage due to food particles. The hindgut consists of the small intestine, colon and rectum, and a

pylorus valve near the anterior end of the small intestine which guards and regulates the passage of digested food from the mid-gut to the hindgut.

The hindgut is a passage for the absorption of a large portion of food moisture and elimination of digested food. In the anterior-posterior direction, the rectum has six muscles for pressing the excrements. The fecal matter is pressed in the rectum and expelled from the anus as fecal pellets bearing hexagonal marks

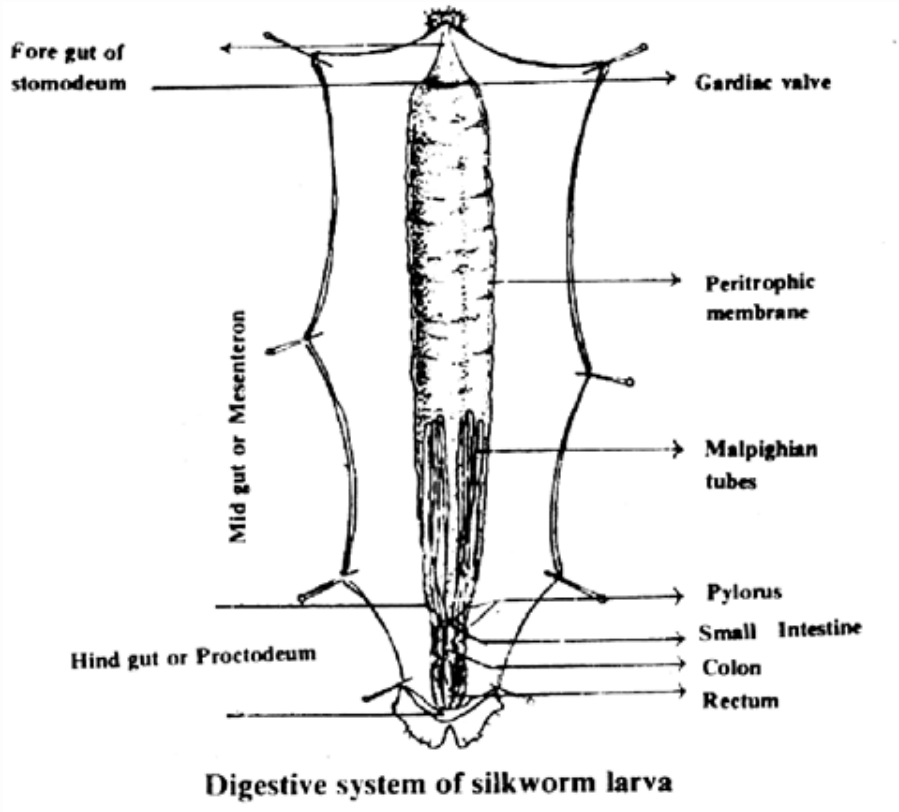


Figure 36: Digestive system of silkworm larvae

5.3 Excretory system of silkworm larva:

In silkworm special excretory organs called **Malpighian**, tubules are present. In the larva the Malpighian, tubes arise at the junction of small intestine and colon in the hindgut of the digestive tract.

The tube arising on each side of the hindgut enlarged into an excretory chamber from which two branches arise. One of the tubes situated on the dorsal side branches further into three tubes.

The three pairs of Malpighian tubes in silkworm larva that stick to the midget and run towards the anterior side.

I. One tube in one-group runs along the dorsal wall of the midget towards the anterior side and turns backwards at the 4th abdominal segment

II. Second tube runs along midget to laterally and turns backwards at the point of center of 4th and 3rd abdominal segment

III. The remaining one tube also passes along ventral wall of the midget and turns backwards at the 3rd abdominal segment.

Then all three tubes are ultimately open in to the rectum. The tubes passing towards the anterior side from the urinary bladder are referred as ascending limbs and the same tube turns back and passing towards rectum are called descending limbs (tubes).

The nitrogenous compounds like protein metabolized by these tubes and excreted principally as uric acid. They also excrete calcium oxalate. The malpighian tubes in the mature larvae are light yellow and their walls contain large quantities of yellow vitamin B_2

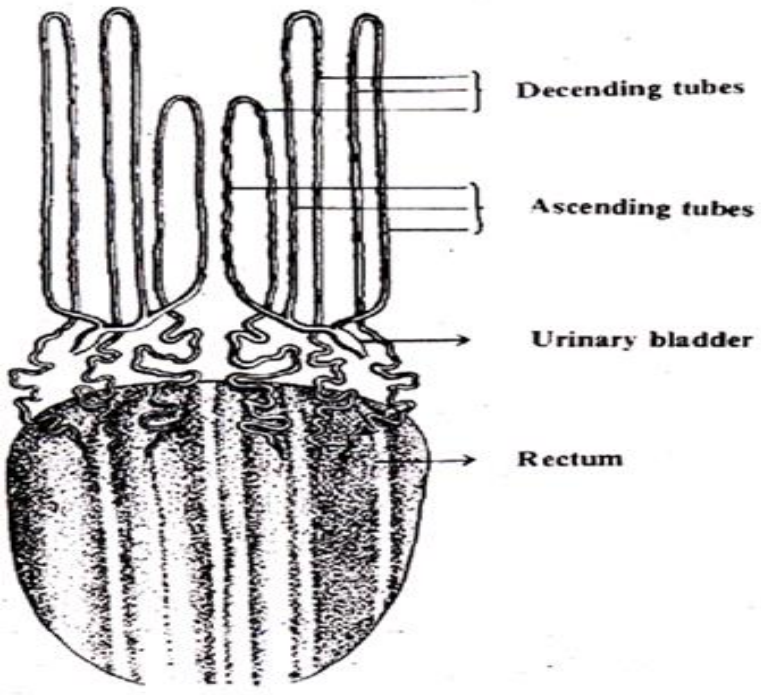


Figure 37: Excretory system of silkworm larva

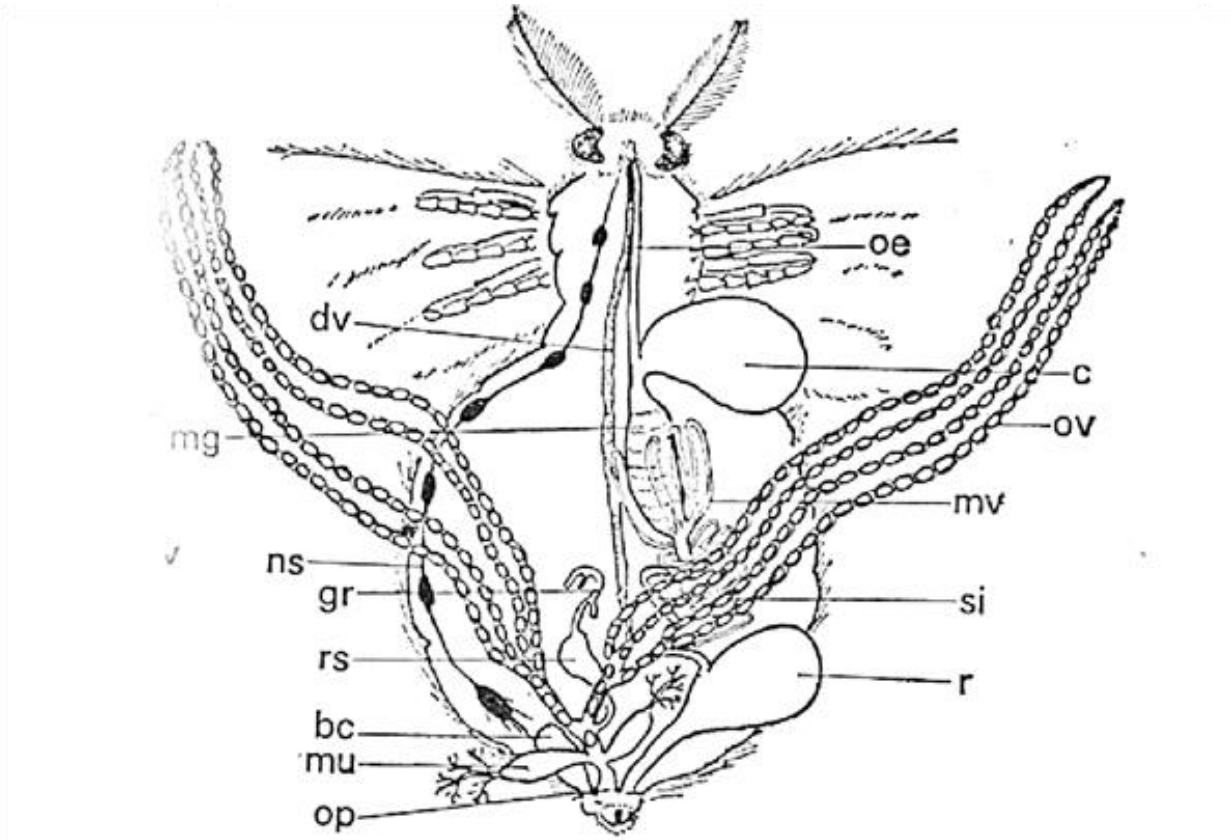
5.4 Reproductive system

In the larva, the sexual phase develops in the late instars when it may be possible to note in the female, a pair of triangular ovaries (gonads) situated on the dorsal side of the sixth abdominal segment; from each of which a blind tube arises and terminates at the eighth abdominal segment. The pair of translucent spots seen ventrally on the eighth abdominal segment is the Ishiwata's forelands and the pair on the ninth abdominal segment is the Ishiwata's hind-glands. These four ventral spots are prominent in the fifth instar and used to identify the female larva.

The male larva consists of a pair of kidney-shaped testes (gonads) on the dorsal side of the fifth abdominal segment and a blind tube, which connected with the Herold's gland - a milky white body-at the center of the ventral side between the eighth and ninth abdominal segments.

In the female moth, paired ovaries occupy most of the abdominal space.
A pair of lateral oviducts arises from the ovaries and unites to form a single, wide common oviduct that ends in the ovipositor at the posterior end of the body. Each of the ovaries carries four egg tubes or ovarioles where the eggs formed. The ovarioles are polytrophic and an alternating succession of nurse cells and oocytes (developing eggs) found in the egg chambers particularly in the pupal stage.

In the adult stage, the four pairs of ovarioles look like coiled strings of beads containing eggs. The *bursa copulatrix* is a saclike structure situated ventrally to the common oviduct and continues as a tube to the outside posteriorly on the eighth abdominal segment. At the time of mating, the *aedeagus* received by the opening, *ostium bursae,* of this tube. The *bursa copulatrix* also opens into the common oviduct by a narrow tube known as the **seminal duct**. Paired accessory glands occur dorsally to the common oviduct. The accessory glands produce an adhesive material, which coats the eggs when they pass down the common oviduct and glues them to the substratum when they laid. The spermathecal is a saclike structure for the reception and storage of spermatozoa and opens into the common oviduct anterior to the accessory glands opening.



bc, bursa copulatrix; c, crop; dv, dorsal vessel; ag, Accessory gland; gr, glandula receptaculi; mg, mid-gut; mu, mucous gland; mv, Malpighian vessel; ns, nervous system; oe, esophagus; op, ovipositor; ov, ovarioles; r, rectum; rs, receptaculum seminis; si, small intestine; t, testes. Note: the relative length of the ovarioles is in fact greater (about 4 to 5 times) than shown.

Figure 38: overall female reproductive system

In male moth, a testis is present in the fifth abdominal segment dorsol laterally on each side of the ventral nerve cord. The *vas efferens* of each testis leads into a *vas deferens, which* opens into the seminal vescicle from where an ejaculatory duct arises and ends in the *aedeagus.* A pair of accessory glands open into the seminal vesicle by a common duct located between the two *vasa deferential.* The membranous sac or the spermatophore formed by the secretion of male accessory glands

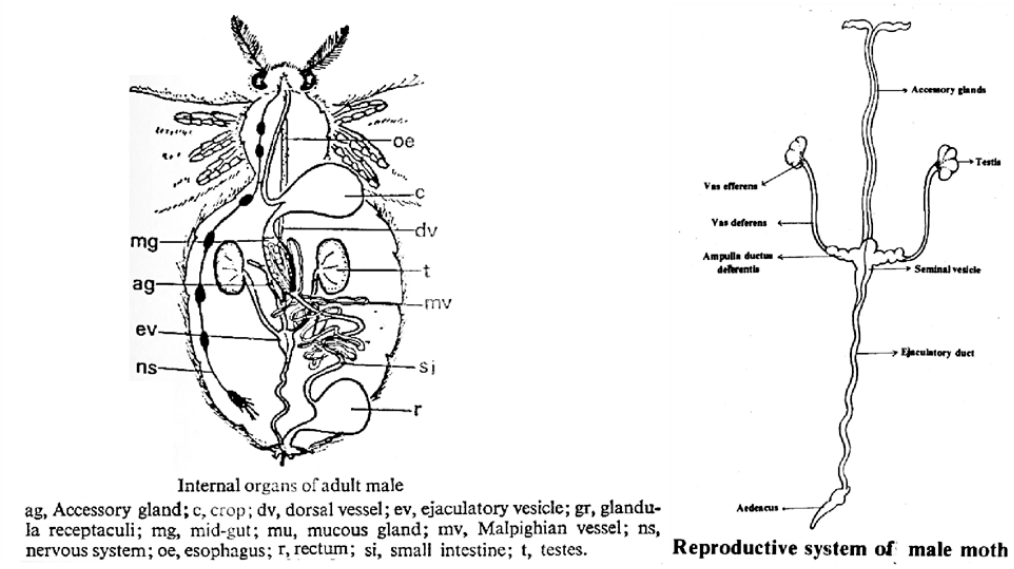


Figure 39: Reproductive system f month

5.5 Respiratory system of silkworm larva

The respiratory function carried out through the spiracles by the movements of the body wall.

In the larva, there are nine pairs of spiracles, one on each side of the pro-thorax from the first to the eighth abdominal segments.

- Periderm, sieve plate and atrium are the parts of the spiracles.
- The periderm forms a ring round the spiracle.
- A slit seen along the median line of the sieve plate inside the ring.
- The external opening of the spiracle leads into a cavity, the atrium that contains the closing apparatus.
- There are two closing membranes and their movement observed if the sieve plate taken off.
- The sieve plate prevents the entry of dust and air.
- A number of tracheal branches start radially from the spiracular cavity
- There are also two large tracheas called main or lateral tracheal trunks connecting all the tracheal bushes.
- The ventral transverse tracheas connect the two tracheal bushes in each segment.

The trachea ramifies repeatedly throughout the body and organs and ultimately form tracheales. When the diameter of the tracheae reduced to one micron, these finer tubules called **tracheales** and they carry oxygen directly to the cells and tissues. Through such a network of tracheae and tracheales, oxygen carried to the various parts, tissues and cells of the body and carbon dioxide removed, through the same channels. The terminus of each tracheales a single cell and the oxygen supply diffused from the tracheales to the cells.

Tracheae are similar in structure to the integument and consist of a supporting thickened ring-like structure called the *taenidium, which* keeps the tubes distended and prevents them from collapsing.

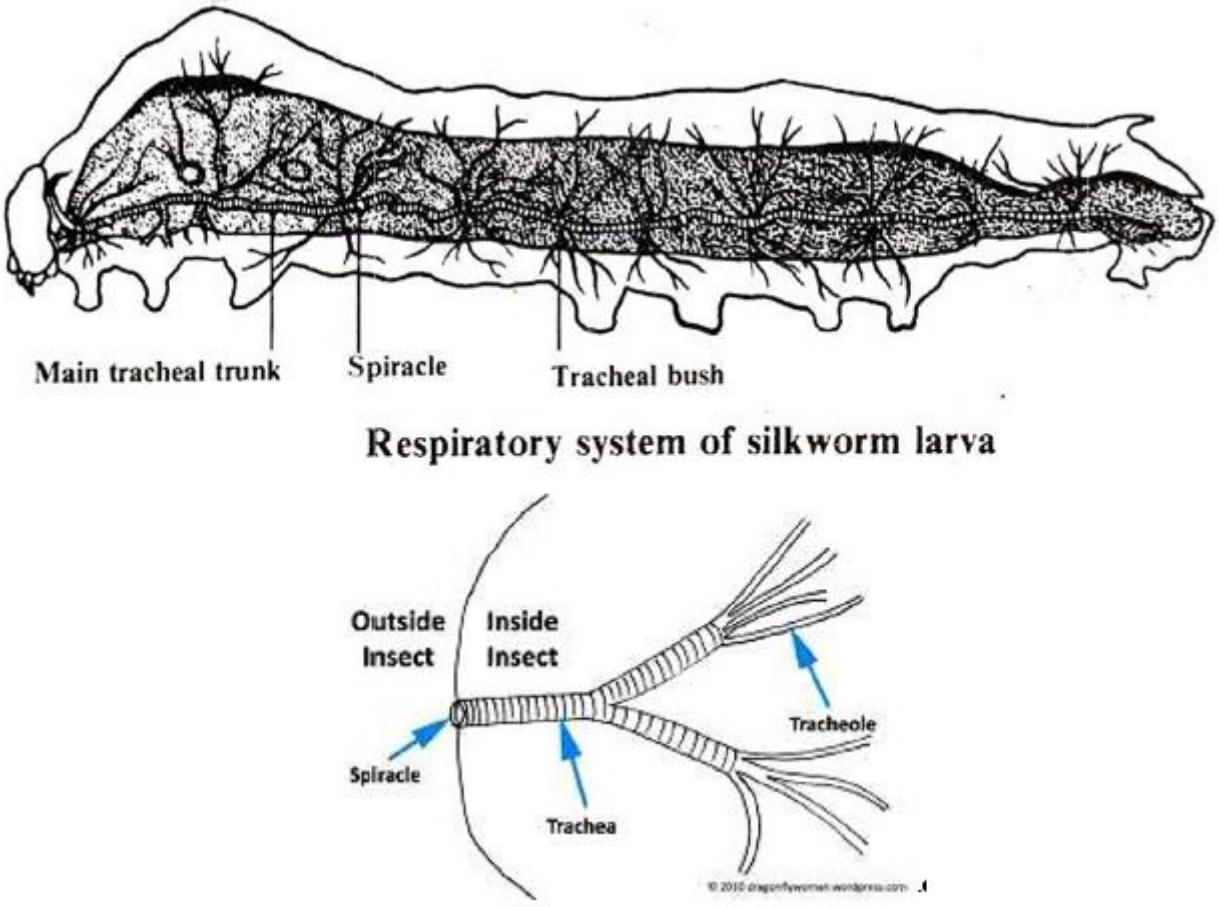


Figure 40: Respiratory system of silkworm larva

Self-Check-5	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Fill the blank space

1. Mention the main organs of the larval body (4%)

_____,_____

_____,_____

_____,_____

_____,_____

_____,_____

2. Write the digestive system of silkworm larvae (3%)

_____,_____

_____,_____

3. Write the three pairs of Malpighian tubes (3%)

_____

_____

_____

Answer the following question!

Note: **Satisfactory rating 6 and 11 points Unsatisfactory 6 below and 11 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: _____ **Date:** _____ Score = _____

Short Answer

L #75	LO #3 Silkworm rearing techniques

Instruction sheet

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- **Determining rearing house preparation and stage of larval rearing.**
- **Carrying out mulberry chow feeding activities**
- **Determining and managing egg hatching**

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to

- Determine rearing house preparation and stage of larval rearing
- Carry out mulberry chow feeding activities
- Determining and managing egg hatching

Learning Instructions:

Read the specific objectives of this Learning Guide.

1. Follow the instructions described below.
2. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them
3. Accomplish the “Self-checks” which are placed following all information sheets.
4. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks)
5. If you earned a satisfactory evaluation proceed to “Operation sheets
6. Perform “the Learning activity performance test” which is placed following “Operation sheets”
7. If your performance is satisfactory proceed to the next learning guide,
8. If your performance is unsatisfactory, see your trainer for further instructions or go back to “Operation sheets”.

Information Sheet 1: Determining rearing house preparation and stage of larval rearing

1.1 Silkworm Rearing House and Equipment

Silkworms reared in a specifically built house with adequate ventilation, light and rodent proof.

Site selection of silkworm rearing house must be:

a) Built away from farm animals' housing

- To avoid drifting of chemicals during spraying.

b) Near to the mulberry field.

- In order to minimize the transportation distance thus cutting down on wilting of leaf.

c) Doors and windows should be North-South direction

- To avoid direct sunlight into the room which could raise the room temperatures and thus cause leaves to dry fast.

The size of the rearing house determined by size of mulberry orchard and amount of silkworm to reared. For example, a small scale farmer with

A 1/4 acre of mulberry orchard needs a rearing house of at least 7m x 5 m (25 ft x 15 ft). Such a house can accommodate 2 cases (40,000) of silkworms.

Locally available house walls building materials are:

- Bamboo
- Off cuts
- Timber
- Stones
- Mud
- Bricks etc. to build the.

Avoid walls made from iron sheets, as it is difficult to regulate house temperatures. However, iron sheet used for roofing. Below is a list of houses that a farmer can choose from depending on his financial capability.

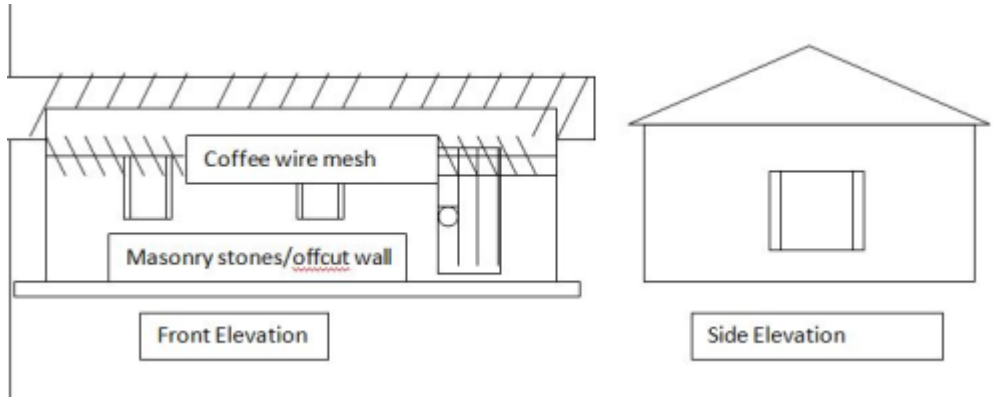


Figure 41: Sketch of a rearing house

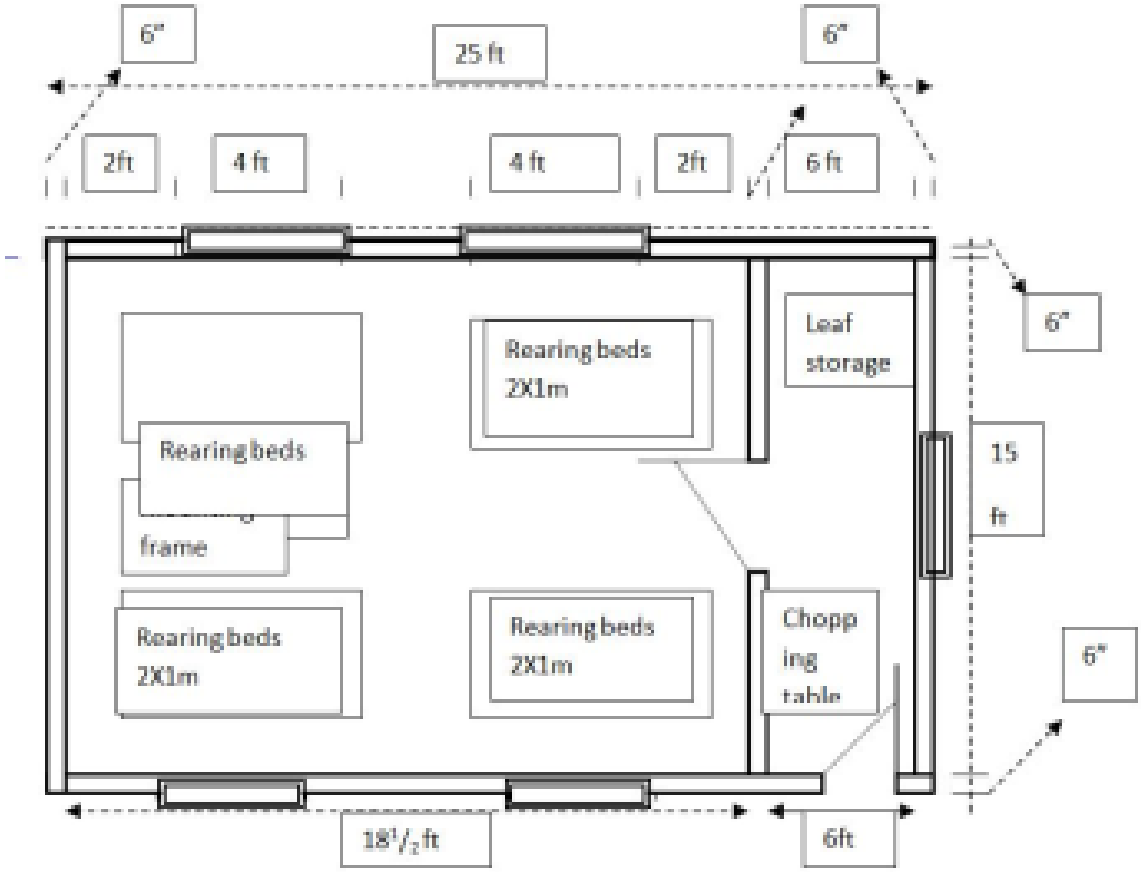


Figure 42: Floor plan of a rearing house

Figure 43: Side view of a timber wall rearing house Front view with a footbath

Figure 44: Model-rearing house (stonewall**)**

1.2 Rearing house

Mulberry silkworm rearing being completely domesticated, demands specified environmental conditions like

- Temperature (24-28° C)
- 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 molting
- Convenient enough to conduct effective cleaning and disinfection**.**

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
- Disease Free Laying; 1 dfl = 500 larvae)

1.3 Rearing appliances

The late age silkworms do not tolerate high temperature, high humidity and poor ventilation. Hence, the rearing house should have cross ventilation facilities to bring down the room temperature and for removal of vapor and harmful gases generated from large quantities of excreta produced by silkworms

Rearing appliances required for rearing 100 dfls (50, 000 larvae

Sl. No.	**Item**	**Quantity**	**Sl. No.**
1	Shoot rearing rack (40’ x 5) 5 tiers	1	1
2	Rotary montages or Chandrika	35	2
3	Power sprayer	1	3
4	Hygrometer	1	4

1.4 Disinfection

Disinfection of rearing house and appliances should be made twice before rearing that is once with 5% bleaching powder (immediately after the completion of previous crop) and another time with 2.5% Sanitech (Chlorine di-oxide) solution just 2 days before the next crop. The schedule suggested for disinfection is given in Table 2.

Schedule of disinfection for rearing house and appliances

Day	Order of work	Details of work
After the completion of previous rearing	1	Collection and burning of diseased larvae and melted and flimsy cocoons.
	2	Flaming the floss of rotary mountange and disinfection by fumigation
	3	First disinfection of rearing house and appliances
5 days before brushing	4	Cleaning and washing of appliances
	5	Sun drying of appliances

4 days before brushing	6	Disinfection of rearing with 0.3% slaked lime (optional
3 days before brushing	7	Second disinfection of rearing house and appliances.
2 days before brushing	8	Dusting disinfectant in front of rearing house and to the passage
	9	Open the windows of rearing house for ventilation
1 day before brushing	10	Preparation for brushing

1.5 Shoot rearing an economical way

In this method of silkworm rearing, the last three stages of rearing conducted by giving mulberry shoots instead of individual leaves. This method is the most economical method of rearing, as it helps to save about 40% of rearing labor. The other advantages are,

- Reduction in contamination and spread of diseases due to less handling of silkworms.
- Secondary contamination reduced, as worms and leaves separated from faces.
- Maintenance of hygienic condition.
- Better preservation of leaf quality both during storing and on the bed.
- Better aeration in the bed.
- Better, cocoon quality and higher survival of larvae.
- Less non-recurring expenditure.

1.6 Feeding

- Initiate feeding with 50-55 days old shoots harvested at the height of 3-4 feet in the cooler hours of the day preferably in the morning. 60-65 days old, shoots fed to fifth age worms.
- The harvested shoots preserved loosely in vertical position in cool and moist place by covering with cleaned, disinfected and wet gunny cloth.
- The quantum of mulberry shoot required is 460 Kg in 4th instar and 2880 Kg in 5th instar for bivoltine silkworms.
- Daily three feeds (6 AM, 2 PM and 10 PM) schedule followed.
- Avoid feeding of soiled or over matured leaves.
- Distribute the larvae uniformly in the bed during every feeding. The bed space required for the worms of 100 dfls at the end of the fifth stage is 600 sq ft.

- Remove the under sized and all suspected diseased worms carefully with chopsticks before every cleaning / feeding to avoid the contamination. The picked larvae put into 2% bleaching powder in 0.3% slaked lime solution.

1.7 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.

1.8 Maintenance of temperature and humidity

- The ideal temperature for the late age rearing is 26° C for III instar larvae, 25° C for IV instar and 24° C for V instar larvae. 80% humidity is required for III instar larvae and 70% is required for IV and V instar larvae.
- Adjust the temperature and relative humidity as per requirement by using cooling, heating and humidifying appliances such as air cooler, room heater, charcoal stove and wet-gunny cloth or by sprinkling water on the roof or using wet sand.
- Good cross ventilation will help to reduce the body temperature of the silkworm.

1.9 Care during molting

- Ensure good ventilation and dry condition in the rearing house during moulting period.
- 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.
- Avoid high fluctuation of temperature and humidity as well as strong wind and bright light.
- Resume feeding when 95% of worms come out of moult

1.10 Maintenance of hygiene

- Wash hands and feet with disinfectant solution before entering in to the rearing house
- To begin with, the hands and feet washed with alkaline soap and then dipped in disinfectant solution (2.5% Sanitech/ Serichlor in 0.5% slaked lime solution or 2% Bleaching powder in 0.3% slaked lime).

- Wash hands in disinfectant solution and water after picking of diseased worms, after bed cleaning and before feeding.
- Pick the diseased worms every day into a basin with lime powder and bleaching powder mixture and dispose off carefully by burning or burying at a distant place.
- Keep the rearing room clean and well aerated during silkworm rearing.

1.11 Application of bed disinfectant

Vijetha, Vijetha Green and Ankush are the silkworm body and rearing seat disinfectants for the prevention of silkworm diseases. The method of usage is as follows.

- Take the powder in a thin cloth and dust over the silkworms @ 5 g/square feet after every moult and once on 4th day of final instar after bed cleaning as given in

Table 3: Schedule and quantity to dusted (for 100 dfls)

Dusting time	**Disinfectant**	**g/sq.ft bed area**	**Quantity required for 100 dfls**
After III moult before resumption of feeding	Vijetha/Vijetha Green/Ankush	5	900
3rd day of IV instar*	Vijetha supplement	3	600
After IV moult before resumption of feeding	Vijetha/Vijetha Green/Ankush	5	1200
2rd day of V instar*	Vijetha supplement	3	1300
4th day of V instar	Vijetha/Vijetha Green/Ankush	5	3000
6th day of V instar*	Vijetha supplement	3	1800

Note: Vijetha supplement recommended for the use during rainy season and winter months to control muscarinic.

- If muscarinic disease is high during rainy and winter seasons, the use of Vijetha supplement recommended preventing this disease.
- Do not dust when silkworm are under moult or on eatable mulberry leaves.
- Feed silkworms 30 minutes after dusting

1.12 Mounting of ripened worms

To obtain such quality cocoons, mounting the silkworm larvae at the appropriate time and good quality montages are essential

In the fifth instar on seventh day silkworms enter into maturation, stop feeding, and begin to search place to build the cocoons. Such larvae picked immediately and mounted on to the montages. Care taken that the number of larvae on montages must not exceed the capacity of each montage.

When the larvae are in spinning stage, the room temperature of 24°C and 60-70 % of relative humidity along with good aeration facility to provide.

Rotary montages recommended for the production of better quality cocoons. About 35 sets of rotary montages required for mounting worms of 100 dfls. For hanging rotary montages, a separate mounting hall or verandah required.

1.13 Harvesting and sorting

- Harvest cocoons on 6th day
- Remove defective cocoons
- After sorting out the defective cocoons grade the cocoons according to the quality.
- In winter, delay the harvest by one day.

1.14 Marketing

Transport the cocoons during cooler hours of the day and market on 7th day. Cocoons need to be loosely packed in nylon netted bags of 30~40 kg capacity and transported in vehicle having shelves/partitions so that pressing of cocoons can be avoided.

1.15 Cocoon yield

The average yield is 60-70 Kg from 100 dfls. About 700-900 Kg cocoon harvested from one acre of mulberry garden in a year.

Self-Check-1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Fill the blank space

1. Write the special requirement of silkworm built (3%)

_____,_____

_____

2. Write the site selection criterial of silkworm rearing house (3%)

_____

_____

_____

3. Write the locally available materials used to build silkworm house (5%)

_____,_____

_____,_____

_____,_____

_____,_____

Answer the following question!

Note: **Satisfactory rating 6 and 11 points Unsatisfactory 6 below and 11 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: _____

Score =

Information Sheet 2: Carry out mulberry chow feeding activities

2.1 Introduction

Domesticated silkworms are the foundation of sericulture. Silkworms predominately feed on mulberry leaves, but the genetic basis for its feeding preference is unknown.

Figure 45: Silkworms and green leaves

For the production of mulberry silk, the sericulture process follows three primary steps.

1. **Mori-culture.** The cultivation of mulberry leaves.
2. **Silkworm rearing**. Promoting the growth of the silkworm.
3. **Silk reeling**. The extraction of silk filaments from the silkworm cocoons.

2.2 Stages of growth and feeding methods

Silkworms undergo four mountings growth stage (instars) in the larval stage and are fed according to these instars.

1st. stage (1st Instar) the young worms should be fed with young tender leaves; 2nd and 3rd leaves from the tip of the shoot. The chopped into small pieces and fed to worms for 4 days at least twice a day in the morning and late afternoon. After the 4 days, the worms go into molt (sleep).

Molting- molting is the shedding of skin as worms enter into the next instar. Molting takes 18 - 24 hours (1 day) and the worms not fed during this period.

The reared must be able to identify when the worms are getting into and out of molt apart from counting days.

Molting Signs:

- woolen heads
- Raised heads
- Worms are immobile

NB: During molting, the bed kept dry and uncovered

Once the worms come out of molt, spread them out evenly to enhance dryness in the bed and to increase the bed space to match with their increasing body size.

Feed the worms when all of them have come out of molt.

Figure 46: 2nd. Instar silkworms

2nd. stage (2nd Instar) feed 3rd and 4th young glossy leaves. Continue feeding chopped leaves for 4 days. After this period, the worms go into molt again

2nd stage (2nd Instar) feed 3rd and 4th young glossy leaves. Continue feeding chopped leaves for 4 days. After this period, the worms go into molt again.

Figure 47: 3rd instar silkworms

3rd. stage (3rd Instar) continue feeding the silkworms on good leaves harvested from the green part of the stem/shoot for three days. After this, period silkworms go into molt.

Figure 48: Attending to silkworms 4th instar silkworms

4th. stage feed worms on whole shoots for 6 Days.

5th. Stage feed on whole shoot for 7/8 days. During feeding always, maintain a single layer of shoots. Avoid over mature, yellow and diseased leaves.

Figure 49: 5th instar silkworms feeding on shoots

Leaf Requirement for Rearing of one Case Silkworms:

stage		Age/Day	Leaf weight	Leaf weight per day	Leaf/shoot remarks per day
1st	1	1st	150 g	-	Harvest 2nd and 3rd young leaves
	2	2nd	200 g	-	
	3	3rd	200 g	-	
	4	4th	150 g	-	
	5	5th	worms sleep	-	
2nd	6	1th	350 g	-	Harvest 3rd and 4th leaves
	7	2nd	450 g	-	
	8	3rd	650 g	-	
	9	4th	700 g	-	
	10	5th	worms sleep	-	
3rd	11	1st	-	2 kg	Harvest leaves that are on the green part of young shoot
	12	2nd	-	3 kg	
	13	3rd	-	3 kg	
	14	4th	-	worms sleep	
4th	15	1st	-	12 kg	Harvest good shoot (1-11/2m) meters long
	16	2nd	-	18 kg	
	17	3rd	-	24 kg	
	18	4th	-	30 kg	
	19	5th	-	40 kg	
	20	6th	-	worms sleep	
	21	7th	-		
5th	22	1st	-	20 kg	
	23	2nd	-	30 kg	
	24	3rd	-	40 kg	Harvest whole shoot.
	25	4th	-	50 kg	
	26	5th	-	60 kg	
	27	6th	-	90 kg	
	28	7th	-	100 kg	
	29	8th	-	50 kg	
	30	9th	-	worms start cocooning	

Self-Check-2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Fill the blank space

1. Write the three primary steps of mulberry silk production process (3%)

_____,_____

_____

2. Mention the silkworm molting sign (3%)

_____,_____

_____

Answer the following question!

Note: **Satisfactory rating 4 and 6 points Unsatisfactory 4 below and 6 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: _____

Score = _____

Information Sheet 3: Determining and managing egg hatching stages

3.1 Management of Silkworm

Silk worms are prone to infection if proper disinfection of rearing house and rearing equipment not done properly.

Disinfection carried out prior to commencement of rearing as a precaution against pathogens, which remain in the rearing house.

The room or house disinfection procedures are:

- Kept airtight during disinfection and should remain closed for 15 - 20 hours after disinfection
- Opened 24 hours prior to introduction of silkworms
- Disinfection is done using 2% formalin solution
- To achieve this, add 1lt of formalin concentrate into 19 lt of water
- Require 40 of formalin solution to cover a room of 5m x 7m x 3m
- Before Disinfection all rearing equipment cleaned and returned into the rearing house
- Bleaching powder spread in a single layer around the house and footbath to maintain hygiene.

Warning: Protective clothing must worn while disinfecting the house

3.2 Controlling temperature and humidity

- Silkworms do well in a temperature range of 23-28^{0}C
  - ✓ High temperatures for the younger worms
  - ✓ Lower temperatures for the older worms.
- Humidity range from 70-85 %
  - ✓ High for the younger worms
  - ✓ Low for the older worms

Temperature and humidity moderated by use of wet gunny bags/wet newspapers hung on the walls or pouring water on cemented floors.

Optimum temperatures and humidity for rearing silkworms of different growth stage (instar) are as follows

Temperature/Humidity

Instars	temperature (^{0}c)	Humidity (%)
1st	26 – 28	85
2nd	26 – 28	85
3rd	24 – 26	80
4th	24 – 25	75
5th	23 – 24	70

3.3 Egg Incubation and Hatching

Silkworm rearing starts with silkworm egg incubation. For healthy development and uniform hatching, eggs incubated under

- Optimum temperature 25^{0}C
- Humidity range 80% - 85%
- Hatching length 10-12 days.

Figure 50: 1 case of silkworm eggs moth (1 batch) Eggs form one silkworm

Figure 51: Newly hatched silkworms

3.4 Brushing (1st Feeding) of Silkworm Larvae

Figure 52: Brushing of Silkworm Larvae Fresh leaves ready for chopping

When the newly hatched larvae appear, they should be gently and carefully transferred to the rearing bed and covered with paraffin paper or clean old newspapers. Covering preserves leaf moisture

3.5. Brushing newly hatched Silkworms

There are two acceptable methods of brushing

1. The hatched worms brushed with a feather from the egg card directly onto the rearing bed. Care must take not to injure the worms.

2. Chop tender (2nd and 3rd leaf) mulberry leaves into small pieces approximately equal to the size of the hatched silkworm larvae and sprinkle over the egg card.

The hatched silkworms will crawl onto the chopped leaves and start feeding. Later the cards removed and larvae still left on paraffin paper or newspaper tapped gently onto the rearing bed. When all larvae are on the rearing beds, then the first feeding given.

Figure 53: 1st feeding (hakitate) Silkworm put together

3.6 Bed Cleaning

Bed cleaning done to remove fecal matter, dead worms and leaf remnants, which would promote fungal growth. It done after every molt for the young silkworms and every other day for the mature worms. Bed cleaning done before feeding worms.

To clean the bed, spread a net over the worms and spread fresh leaves on top of the net. Worms will crawl up to feed on the fresh leaves on the net. Transfer the worms using the net to another clean bed/tray. Remove any remaining worms then discard the waste into a compost pile. Spread the worms well then feed them.

Figure 54: Bed cleaning

3.7 Silkworm Density/Spacing of Worms

Different stages of silkworms require different bed space. Spread worms evenly ensuring that they do not overlap each other

As silkworms increase in size, transfer some to another bed/tray to avoid overcrowding. Overcrowding leads to underfeeding, creating a microclimate for disease spread and could lead to suffocation.

Rearing Density of 1 Case of Silkworm

stage	Early period	Middle period	Later period	Magnification
1^{st}	$0.3m^2$	$0.4m^2$	$0.6m^2$	$1.0m^2$
2^{nd}	$1.0m^2$	$1.3m^2$	$1.6m^2$	$2.0m^2$
3^{rd}	$2.0m^2$	$2.4m^2$	$3.0m^2$	$4.0m^2$
4^{th}	$4.0m^2$	$5.0m^2$	$7.0m^2$	$8.0m^2$
5^{th}	$8.0m^2$	$12.0m^2$	$16.0m^2$	$17.0m^2$

3.8 Mounting

Mounting is transferring mature silkworms from rearing beds to montages to start spinning. Spinning starts 8 days after worms get into fifth (5^{th}) stage.

A. Signs of Maturity

- Larvae cease to feed and crawl restlessly in search of a corner to attach themselves for spinning.
- They move to corners of the rearing beds ready to spin
- If picking of mature silkworms is delayed the worms spin on teh bed and silk fiber is found on the bed
- The worms appear cream white as they are full of silk
- They appear shrank in length

B. Process of Mounting

The mature worms picked from the rearing beds and transferred to montages. Care taken to put the right number of worms on the montages to avoid overcrowding and formation of double cocoons.

Figure 55: Picking mature worms

N.B: Diseased worms picked separately and discarded either burning or burying.

C. Mounting Density

90-100 larvae mounted per square foot ($1ft^2$)

Figure 56: Well-spaced silkworms on montage Silkworms on a rotary montage

Papers spread on the floor below the montages to absorb urine from the worms and changed when they become damp

D. Environmental conditions for mounting

- Temperature not exceed 26^0C
- Humidity between 60-70%.

The two parameters affect the quality of cocoons (reliability). While spinning there should be minimal disturbance to the silkworm.

Figure 57: A mature spinning silkworm partially spun cocoons

Figure 58: Fully spun cocoons on rotary montages

Figure 59: Fully spun cocoons on timber montage

3.9 Harvesting Cocoons

Cocoons harvested on the 7th to 8th day from the inception of spinning. By this time, the worm will have completed spinning of cocoon and transformed into pupa. To confirm this, cut 2 or 3 cocoons to check whether pupae are fully formed. The optimum time for harvesting is when the pupae turn brown in color and become hard.

Figure 60: Fully formed pupa

Figure 61: Sericulture production cycle (rearing silkworm upto coceen hervesting

Self-Check-3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Fill the blank space

1. Write the room or house of silkworm disinfection procedures (5%)

_____,_____

_____,_____

_____,_____

2. Write the temperature and humidity range requirement based on the silkworm age (3%)

_____,_____

_____,_____

3. Write the optimum temperature and humidity range required for silkworm incubation (2%).

_____,_____

4. Write the length of silkworm hatching (2%)

_____

5. Write the two methods of brushing newly hatched Silkworms (2%)

_____,_____

6_____ transferring mature silkworms from rearing beds to montages to start spinning (2%).

Answer the following question!

Note: **Satisfactory rating 8 and 15 points Unsatisfactory 8 below and 15 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: _____

Score =

L #76	LO #4 supervise postharvest handling of silk

Instruction sheet

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Selecting, using and maintaining suitable post-harvest handling
- preparing PPE, materials, tools and equipment
- Undertaking cocoons stifling and drying methods.
- Carry out cocoon sorting activities
- Storing dried cocoons in a well-ventilated place.
- Carry out di-flossing of cocoon
- Cooking cocoons and brushing.
- Transferring the cocoons to the reeling basin.
- Carry out cleaning of boiled cocoon and doing spinning operation
- Reeling filaments of 7-9 cocoons together
- Doing re-reeling of reeled thread
- Doing testing and grading operations
- Doing lacing
- Carry out skeining.
- Doing book making and bailing to transport

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Selecting, using and maintaining suitable post-harvest handling
- preparing PPE, materials, tools and equipment
- Undertaking cocoons stifling and drying methods.
- Carry out cocoon sorting activities
- Storing dried cocoons in a well-ventilated place.
- Carry out di-flossing of cocoon
- Cooking cocoons and brushing.
- Transferring the cocoons to the reeling basin.
- Carry out cleaning of boiled cocoon and doing spinning operation
- Reeling filaments of 7-9 cocoons together
- Doing re-reeling of reeled thread
- Doing testing and grading operations
- Doing lacing
- Carry out skinning.
- Doing book making and bailing to transport

Learning Instructions:
Read the specific objectives of this Learning Guide. 1. Follow the instructions described below. 2. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them 3. Accomplish the “Self-checks” which are placed following all information sheets. 4. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks) 5. If you earned a satisfactory evaluation proceed to “Operation sheets 6. Perform “the Learning activity performance test” which is placed following “Operation sheets” 7. If your performance is satisfactory proceed to the next learning guide, 8. If your performance is unsatisfactory, see your trainer for further instructions or go back to “Operation sheets”.

Information Sheet 1: Selecting, using and maintaining suitable post-harvest handling

1.1 Maintaining physical and chemical properties of silk

1. Specific gravity

The bave specific gravity on average of sericin and fibroin measures from 1.32 to 1.40. Generally, the specific gravity of sericin is slightly higher than that of fibroin

Specific gravity and tensile strength of various fibers

Fibers	Specific gravity	Tenacity (g/denier)	Elongation (%)
Raw silk	1.32-1.40	2.6-4.8	18-23
Degummed silk	1.30-1.38	-	-
Wool16	1.30-1.40	1.2-1.5	30-48
Cotton	1.52-1.60	3.2-4.8	7-11
Flax	1.50-1.58	4.8-6.0	2-4
Nylon	1.14-1.17	4.5-5.0	25-30

2. Tenacity and elongation

Tenacity indicates the quantity of weight a given fiber can support before breaking.

- The typical tenacity of a bave is 3.6 to 4.8 g per denier.
- Degummed silk has greater tenacity than raw silk
- Elongation defines the length to which a fiber stretched before breaking.
- Raw silk has an elongation of 18 to 23 percent of its original length.
- Excess moisture increases the elongation of silk, but decreases its tenacity.

3. Hygroscopic nature

$$\text{Denier (D)} = \frac{\text{Fibre weight (g)}}{\text{Fibre length (m)}} \times 9\,000$$

Moisture content and humidity are of critical importance to commercial silk production. Illustrates the pattern of moisture regain where a hysteresis exists between the adsorption and desorption curves. Desorption measures a greater regain at a given relative humidity. For instance, given 65 percent RH, the adsorption regain value is 10 percent and the associated desorption value is 11.1 percent. Currently, 11 percent is the

accepted moisture regain coefficient for silk; the mercantile weight of silk derived based on this factor.

4. Manage effect of light

Continuous exposure to light weakens silk faster than cotton or wool. Raw silk is more resistant to light than degummed silk. It is advised that silk drapery and upholstery fabrics be protected from direct exposure to the light

5. Electrical properties

Silk is a poor conductor of electricity and accumulates a static charge from friction. This trait can render it difficult to handle in the manufacturing process. This static charge dissipated by high humidity or by maintaining a R.H. of 65 percent at 25ºC.

Based on its insulating properties, silk used extensively for covering wire in electrical equipment.

6. Action of water

Silk absorbent fiber, which readily becomes impregnate with water. Water, however, does not permanently affect silk fiber. Silk strength decreases about 20 percent when wet and regains its original strength after drying.

The fiber expands but does not dissolve when steeped in warm water. Note that the fiber will also absorb dissolved substances present in water. This is the reason that special attention given to the quality of the water utilized for reeling, washing, dyeing or finishing.

7. Effect of heat

If white silk heated in an oven at 110ºC for 15 minutes, it begins to turn yellow. At 170ºC, silk disintegrates and at its burning points releases an empyreumatic odor.

8. Degradation by acids, alkalis

Treatment of silk fibers with acid or alkaline substances causes hydrolysis of the peptide linkages. The degree of hydrolysis is based on the pH factor, which is at minimum between 4 and 8. Degradation of the fiber exhibited by loss of tensile strength or change in the viscosity of the solution.

Hydrolysis by acid is more extensive than alkali, and it postulated that acid hydrolysis occurs at linkages widely distributed along the protein chain, whereas in the early stages of the alkaline treatment, hydrolysis happens at the end of the chain. Hydrochloric acid readily dissolves fibroin especially when heated and this used mainly in studies of hydrolysis. Hot concentrated sulphuric acid, while rapidly dissolving and hydrolyzing fibroin causes sulphation tyrosine.

Nitric acid readily decomposes fibroin, due to its powerful oxidizing properties and concurrently causes nitration of the benzene nuclei. Organic acids have few effects at room temperature when diluted, but in a concentrated form, fibroin dissolved, along with a certain amount of decomposition.

9. Proteolytic enzymes

Proteolytic enzymes do not readily attack fibroin in fibrous form apparently because the protein chains in silk densely packed without bulky side chains. Serious degradation caused by water or steam at 100ºC.

10. Oxidation

Reports regarding the oxidation of proteins are rather meagre since the reactions are very complex. Oxidizing agents may attack proteins in three possible points:

a) At the side chains,

b) At the N-terminal residues, and

c) At the peptide bonds of adjacent amino groups.

Hydrogen peroxide absorbed by silk and thought to form complexes with amino acid groups and peptide bonds. It demonstrated that hydrogen peroxide diminishes the tyrosine content and further that the peptide bonds are broken at the tyrosine residues. Per acetic acid causes more rapid scission and produces more acid groups than peroxide.

11. Other agents

Chlorine attacks fibroin more vigorously than does sodium hypochlorite. The oxidation is mainly at the tyrosine residues.

1.2 Maintaining Factors influencing cocoon quality

This section presents the measures taken during silkworm rearing and mounting to obtain a better quality of cocoons with higher silk content, longer filament, better reliability and lower percentage of defective cocoons.

1. Temperature and humidity during mounting

Maintain temperatures at or near 25ºC and relative humidity around 65 percent for silkworms to spin good quality cocoons with a high reliability.

2. Mounting device

Although different mount practices employed among producer countries, rotary mounting frames provide good ventilation. The result is improved reliability of cocoons.

3. Harvesting and handling of fresh cocoons

Cocoons harvested only following complete pupation. In practice, the appropriate harvesting day would be the fifth day in tropical countries, and the seventh or eighth day in temperate countries, from the mounting date. If premature harvesting takes place, the silkworm will still be in its larval stage, weigh more, have fragile skin, and could likely be crushed, which would cause stains to the cocoon during handling and transportation.

4. Transport of fresh cocoons

After proper harvesting and removal of diseased or damaged cocoons, the fresh cocoons taken to the market. For short distances, the farmer carries the cocoons in bamboo baskets or jut bags on his head or by bicycle.

If the distance longer, cocoons transported in a van or a bus. Caution exercised when loading fresh cocoons on to the van to ensure that containers loosely packed in tiers to avoid damage.

Vibration and shock during long trips can spoil fresh cocoons. Cocoon quality affected by steam produced while being transferred in a bag or basket. If there are defective cocoons fresh, cocoon quality harmed.

First use of P.V.C. containers with 15 kgs capacity recommended. Shock absorbers, such as sponge can prevent damage over long distances.

To minimize the risk of heat deterioration, shipping should take place only during the night or early morning. Ideally, the fresh cocoons should arrive at the stifling unit within two to three days after harvest.

Effect of transportation containers of fresh cocoons on reeling results

Transportation containers	Raw silk yield (%)	Cocoon reelability (%)	Reeling troubles per 10,000m (times)	Neatness (%)	Cleanness (%)
Bamboo basket with cotton bag	18.50	71.1	2.17	93.0	95.0
P.V.C. container with sponge (shock absorber)	18.75	75.0	1.83	96.5	96.5

Information Sheet 2: Preparing PPE, materials, tools and equipment

2.1 Silkworm rearing equipment, material and tools

The minimum economic unit is 1/4 acre of Mulberry, which can rear two cases of silkworm (40,000 silkworms). One requires the following equipment:

1. Rearing beds

There are different types of rearing beds.

- Farmers advised to use locally available materials to keep the production cost as low as possible. Below are some of the rearing beds that farmers can adapt.

Figure 62: 16 trays of 2 m x 1 m stacked 32 rearing trays of 1 m x 1 m with 6 rearing stands to carry 6 trays each.

Figure 63: Rearing beds

2. Bed cleaning nets

3. Old newspapers or brown paper

4. Montages for spinning, -260 partitions and 26 rotary frames: Montages made from timber, carton, hard paper, plywood or wire

5. Leaf picking bags

6. Chopping knives

7. Chopping boards

8. Chopping table

9. Feathers

10. Foam rubber strips

11. Ant wells

12. Knapsack sprayer

13. Secateurs

14. Jiko

Information Sheet 3: Undertaking cocoons stifling and drying methods

3.1 Methods of stifling and drying

Cocoon stifling and drying killing the pupa inside the cocoon.

Purpose of Cocoon stifling and drying are:

- To avoid moth emergence and there by preserving the continuity of the silk filament
- To protect the cocoon quality
- To preserve the cocoons for reeling
- Dried cocoons can be stored for a longer period with our purification and molds

In countries like Japan that have advanced techniques of sericulture, bivoltine cocoons are dried using hot air generated by electricity or steam. This modern method is only suitable for bivoltine species

In tropical areas where multivoltine cocoons predominate, the main procedure steam stifling

The three methods of cocoon drying in commercial are:

1. Sun drying

No investment required to kill pupae and dry cocoons in bright sunshine. Clearly, this is only possible in tropical and sub-tropical zones. Fresh cocoons spread in thin layers on a mot or planks of wood and exposed to direct sunlight.

Depending on the strength of the sun, the process takes two to three days. Though cheap and simple to employ,

The main disadvantage silk fiber's sensitivity to ultra-violet rays, which harm fiber strength and color. Limited facilities for quick marketing of cocoons, sun drying continues utilized in many tropical and sub-tropical countries

2. Steam stifling

Generally, in many tropical and sub-tropical countries, fresh cocoons heaped into basket and steamed in small reeling units.

In big reeling units with a boiler, the steam chambers used for stifling. Chamber steaming represents an improvement over baskets as the cocoons spread in thin layers.

Steam works well for multivoltine cocoons, which soft and reel easily without long periods in storage. After steaming, these cocoons easily cooked in an open pan, a method commonly used in India.

Steam rapid as pupae killed within 30 minutes. Immediately after stifling, the cocoons spread on spacious, well-ventilated shelves and left for three to four days partial drying prior to reeling

The cocoons must turned over frequently to prevent the growth of mold. If left for extended periods, such as more than a month, the risk of mold pronounced even with frequent turning and satisfactory ventilation. This damage especially acute during the rainy season.

Example:

- Basket steaming
- Chamber steaming

Figure 64: Basket steaming Chamber steaming

Figure 65: Stifling chamber

3. Hot air-drying

The hot air drying method is very common for bivoltine cocoons in Seri culturally advanced countries.

The hot air dryer essentially comprises:

i. Drying chamber, in which fresh cocoons are placed preferably in thin layers
ii. A fan to maintain constant and uniform air current throughout the layers along with an efficient ventilator to drive out moisture avoiding condensation inside the chamber, and
iii. A heater for heating the air driven by the fan. Precise thermostatic control for regulating the temperature installed in the drying.

09

Information Sheet 4: Carry out cocoon sorting activities

4. Sorting of cocoon

The defective cocoons sorted out by the reared before taking the cocoon crop to market Even then, the cocoons again sorted before reeling.

Further cocoon may become defective in the process of transporting, stifling, storing etc.

Silkworm farmers remove defective cocoons as well as the double cocoons before taking the produce to the market. Still there may be a small percentage of defective cocoons, which would have escaped preliminary sorting. Hence, cocoons require a second sorting to ensure uniform good quality cocoons for reeling

The second sorting a must before reeling, to get good quality, uniform cocoons.

Cocoons such as

- Double cocoons
- Stained and Crushed
- Cocoons with print of cocoons frame
- Flimsy
- Thin shelled cocoon
- Malformed/immature cocoon
- Pierced cocoon
- Fluffy
- Insect damaged
- Mold attacked are found in small quantities which are removed and rejected, for production of high grade raw silk

The double cocoons used for duping silk

There are two methods of sorting

1. Sorting before stifling
2. 2.Sorting after stifling

Immediately after the cocoons received in the cocoon stores, flimsy, stained and method cocoons picked out and separated. These can easily see in the cocoon lot. If these not sorted out, they will spoil the good cocoons by staining and increase the number of defective cocoons. After stifling and drying the cocoons subjected to sorting and later grading.

The workers who are the called sorters entrusted with the sorting. Each sorter given specified quantity of cocoons and the workload fixed. If the storing is improper, it results in high percentage of defective cocoons, which are unfit for reeling

The type of defect generally encountered in the second sorting are double cocoons, crushed and stained cocoons, cocoons with prints of cocooning frame, flimsy cocoons and insect damaged cocoons, thin shelled cocoons and moldy cocoons.

1. Method of sorting

The cocoons spread out on tables with low partitions and the sorters sit around the tables and pick out the defective and double cocoons by visual inspection.

The sorting room generally located close to the cocoon stores and provided with good ventilation and lighting.

Rejections placed in a separate container. In the procedure described above, only obviously defective cocoon rejected. This system of sorting, therefore, does not commend itself to modern techniques of reeling, which aim at producing predetermined qualities of raw silk.

In advanced countries, the sorters detect even internally damaged cocoons and eliminate them by passing the cocoons over ground glass plates illuminated from below. These glass plates generally measure about 38 x 38 cm^2 and fitted cutouts of equal size in a lamp blacked table top or moving platform

A fluorescent light or sometimes even an ordinary 60-watt frost lamp placed in a suitable position under the platform provides the required illumination from below

When defective cocoons containing decomposed pupa and those with the inside discolored pass over the glass plate they easily detected. This method of sorting not only enables thorough sorting but also is also economical, since the sorting work made easier for the workers.

2. Cocoon mixing

In most modern factories, which aim at producing high-grade raw silk, the kinds of cocoons graded in the visual inspection or mechanical test actually mixed in required proportions. This called cocoon mixing or blending and done to ensure speed and uniformity of reeling as well as to obtain the desired effect in raw silk. This sort of blending of cocoons found to be quite essential for ensuring a high degree of efficiency of automatic reeling machines.

Qualities of raw silk reeled from sorted cocoons (Song and Choe, 1970)

Items	Cocoons with decomposed pupa	Inside stained cocoons	Fluffy cocoons	Outside stained cocoons	Thin shell cocoons	Frame printed cocoons	Good cocoon
Cleanness (%)	74.8	83.7	85.8	85.1	84.5	93.4	95
Average neatness (%)	76.0	88.7	80.6	86.7	87.0	89.4	91
Low neatness (%)	69.3	78.8	73.3	78.5	80.0	82.3	83
Grade	E	D	E	C	D	A	2A

Information Sheet 5: Storing dried cocoons in a well-ventilated place

5.1 Introduction

Raw silk is vulnerable to heat and sunlight, which may alter its color, while moisture may cause fungal attack. Thus, precautions must take to store raw silk.

The storeroom must maintain control over temperature and humidity. BHC powder, chloropicrin, naphthalene and other repellents utilized to counter damage from insects. Open skeins should not store over long periods; properly packed books and bales can be stored for extended periods under strict atmospheric conditions with no deterioration to the raw silk quality

5.2 Storage of cocoons

It is one of the important aspects of reeling. It is a problem when stifled cocoons (univoltine) are to be stored for a long time. Cocoons completely dried before storing. Even completely dried cocoons also sometimes damaged by mold attack if the storage room not kept dry. Other problem in storing is Dermestes betel pests. It feeds on the fat content of the pupae for which is cuts the silk shell and damages the cocoons.

The beetle attracted by the smell of purifying pupae. Sometimes rats also cause damage to the cocoons. The color of the cocoon affected if not stored properly. After complete drying, the cocoons stored in a storehouse which is protected from rats and is moisture proof

To protect the cocoons from fungal attack, the inside temperature and relative humidity of the store need to be maintained at 27^0C to 30^0C with 60-70 percent relative humidity.

The following tips adopted for safe storing:

- All the spotted and stained cocoons are collected from healthy co-coons and thrown away
- Waste cocoons and silk are stored far away from the store room

- Store house should be protected from direct sunlight but proper aeration is essential
- Walls and ceiling disinfected with 2% formalin
- If any insects are found in stored cocoons all the cocoons are passed through dry hot air at 60^0-70^0C for some time to kill the insect population.
- Cocoons should always be kept in thin layers on trays and kept open for natural evaporation

5.3 Preventive measures to control molds

- Mold develops when the cocoon store is damp and humid and when the cocoons are not fully dried. It is necessary to ensure complete desiccation of cocoons before storing
- Humidity should not rise above 70% in the store house
- Store room must possess good ventilation
- Cocoons should be given regular and frequent turning during storage
- When fumigants are used care is taken to keep the doors and windows open till the traces of fumigants are removed

5.4 Cocoon storage

- Air space for ventilation
- Humidity should not exceeds70%
- Temperature should be 27%

Information Sheet 6: Carrying out di-flossing of cocoon

6.1 Introduction

De-flossing After harvesting all loose fiber on cocoons surface removed, giving it a clean look, ready for the market. Failure to de-floss cocoons lowers the marketability of the cocoon

6.2 De-flossing of cocoon

De-flossing is an important and necessary of reeling

- The cocoons with floss obstructions in mechanical processes and results in slowing the operation and increases wastage of material, labor and time
- The superficial floss must remove.
- In the earlier stages of reeling operations, the floss protects the proper well-laid reel able layer of the cocoons

The multi-volatile cocoons are generally flossy and medium firm-ness in build. Such cocoons de-flossed by the sorters by peeling the floss from the cocoon with the fingers. This process may be laborious but the obvious advantage is that required quantity of floss removed from the cocoons. However, the process consumes too much time

Univoltine cocoons are naturally firm in build and contain less floss. Such cocoons de-flossed using a rough surfaced iron rod of 60-65cmlong one cm thick. One end of the rod bent into the shape of a handle. The handle of the rod held in the toes of the sorter's food and long end of the rod thrust a little below the surface layers of cocoon heap. When sorter turns the handle, the iron rod collects round itself the floss

In advanced countries, a simple hand operated de-flossing machines used. However, this is not suitable for too flossy cocoons and shells which not robust and firm

6.3 Riddling

This process helps to separate the cocoons according to their sizes.

The de-flossed cocoons when fed to riddling machine, they separated and collected as large, medium and small sizes. This process is more use full.

The cocoons separated using simple sieves or mechanical operations reeled since only uniform size cocoons offer scope for production of high-grade silk.

There are appliances, which combine de-flossing, and riddling operations. They consist of two distinct but connected parts. The first part de-flossed the cocoons while second one riddles the cocoons

6.4 Mixing

In some modern filatures, which aim at producing special quality raw silk, three varieties of cocoons graded in riddling machine mixed in required proportions. This process of combining cocoons called cocoon mixing or blending. It helps to ensure speed and uniformity of reeling and to get desired effect in raw silk. It is essential for ensuring a high degree of efficiency of the automatic reeling machines. However, with advent of the denier control mechanism, cocoon mixing have lost its importance

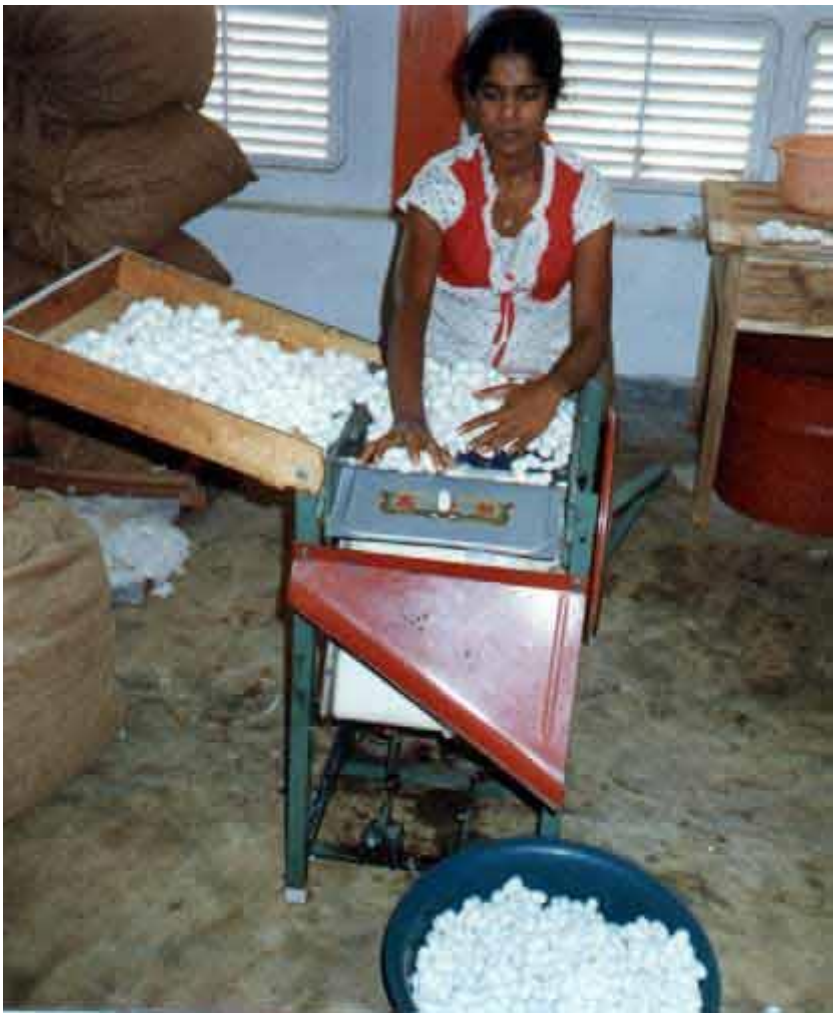


Figure 66: Cocoon de-flossing machine

Figure 67: Harvested cocoons De-flossed cocoons

Information Sheet 7: Cooking cocoons and brushing

7.1 Introduction

The silkworm cocoon is a ball of silk filament who is one end is inside and the other outside. The filament is continuous and consists of fibroin in the middle core, with a serial layer covering the fibroin. As the bave winding in the cocoon are held fast by the natural gum serein, it is necessary to soften the gum by putting the cocoon in hot water before un-winding the bave

The product of the reeling operation called grange or raw silk. Reeling is the process of unwinding of cocoon filament or baves and winding these filaments to a minimum size of 14 deniers.

Reeling is not an easy job as the baves bound by a hard gum like protein known as serein. Hence, the serein has to be melted so that fibroin which the main constituent of the cocoon filament is liberated free. The process of softening popularly known as cooking or boiling. Further, this process also helps brushing the entangled floss layer of the cocoon from the true end of relabel filament. One has to be very clear about the favors to analyze the factors that control unwinding of the cocoon filament. Thus the details of serein protein. Properties of silk, cooking process. Brushing methods detailed in this chapter

7.2 Cocoon cooking

Cocoon cooking unwinds the cocoon filament spun by the silkworm. The servicing covering around the cocoon filament agglutinated after silkworm spinning, the hardened through the cocoon drying process. In preparation for reeling softened.

Processing softens serein by heat, water and steam. Ideally, there will be uniform softening of the outer and inner cocoon shell.

Cocoon cooking methods

A. Pan cooking

1.1 Cocoons put into a pan of boiling water.

The groping ends of the cooked cocoon completed with the stirring rod in the pan

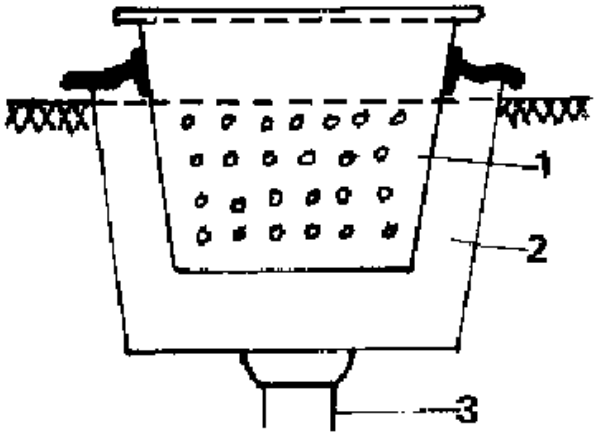


Figure 68: Pan cooking basin Single pan cooking

1.2 The cocoons contained in the wire cage placed into the boiling water and then boiled for a few minutes.

After boiling, the cocoons with the wire cage moved into a low temperature bath in another pan. If there is water permeation inside cocoon shell and swelling of the cocoon shell, this work repeated

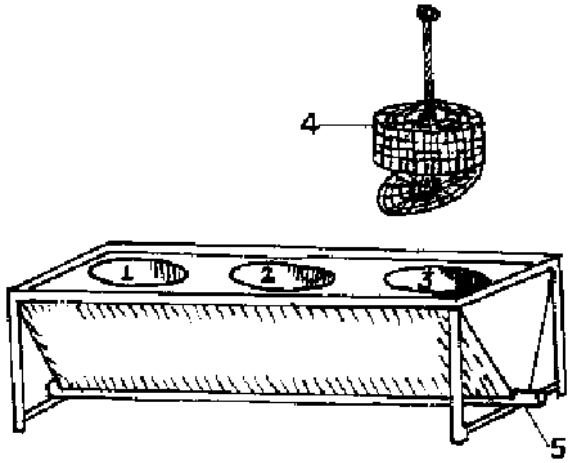


Figure 69: Three-pan type cooking appliance Tree pan cooking

B. Machine cooking

Recently, machine cooking has become widely used in most silk reeling factories

In general, the machine cooking process divided into six parts as follows:

1. Soaking part

- The surface layer of the cocoon swells over at the soaking part.
- The first part carried out by dipping the outer layer of the cocoons into a water bath at 55ºC
- This step comparable to fabric dipping for dyeing to ensure even results.

2. High temperature and low temperature permeation part

The uniform cooking of the outer and inner layers of the cocoon easily attained by replacing the air of the cocoon cavity with water since water transfers heat faster than air. The wet cocoons from the soaking part are exposed to steam at about 90-95ºC at an appropriate steam pressure. Next, the air inside the cocoon cavity is heated. When cocoons treated at high temperature permeation moved into low temperature permeation around 65ºC, partial condensation occurs in the cocoon cavity. Then the cocoon sucks water in, evenly wetting all the layers of the shell.

The amount of water permeated into the cocoon cavity controlled by the difference in temperature between high temperature and low temperature permeation parts, as well as the air permeability of the cocoon shell.

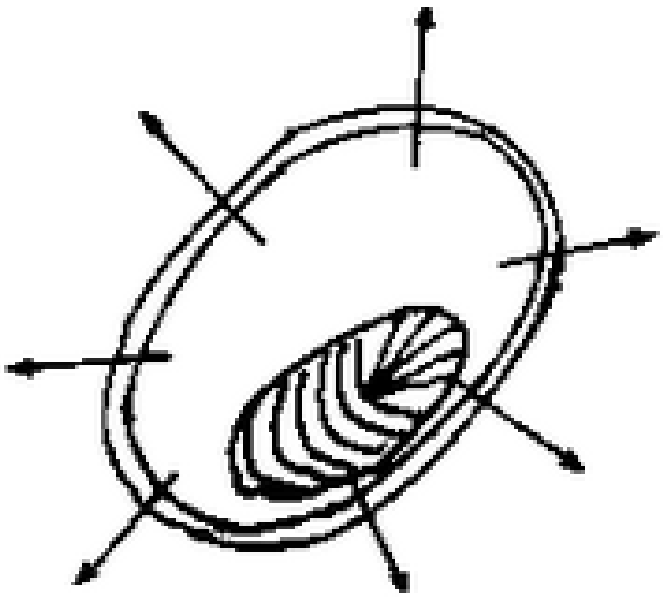


Figure 70: Air expansion in cocoon cavity and partially replaced with steam at high temperature permeation part.

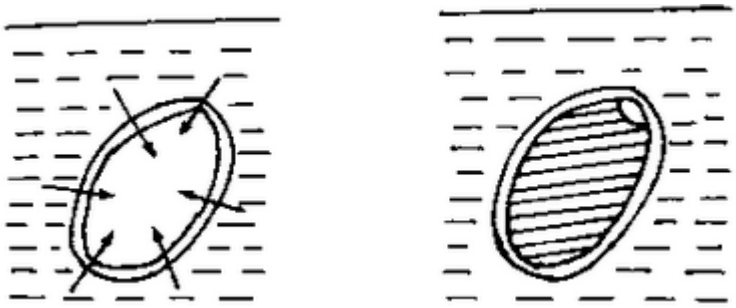


Figure 71: Cocoon sucks in water at low temperature permeation part

3. Steam cooking part

Now the cocoons treated in steps 1) and 2*)* moved to the steam processing. This part causes the serein to swell and soften the silk layers and the steam to fill up the cocoon cavity by diffusing the permeated water out of the cocoon. Steam heat is a highly efficient head conductor that can cause unwanted serein loss.

To minimize or stop this loss of serein, infrared rays attempted in this process, but proven unfeasible. For cocoons anticipated having poor reel ability, the steam cooking part has to be prolonged.

Sudden variations in steam pressure can adversely affect the cooking process by producing over processed or insufficiently processed cocoons. These poorly cooked cocoons seriously deteriorate reeling efficiency by decreasing raw silk yield and quality and boosting cleanness defects during reeling. It urged that greater vigilance exercised to control steam cooking.

4. Cooking adjustment part

At this point, the steam content of the cocoon cavity replaced with water through gradual condensation of steam in the cocoon. This effected by gradually cooling of the water from 98º to 65ºC. Serein swollen by steam cooking becomes stable. As this step consumes large volumes of water for cocoon permeation, it needs to be longer in duration and requires more fresh water than other parts.

5. Low temperature-finishing part

Cocoons are finished in 50-60ºC water

The cocoons, which properly swollen by processing in the first five steps, become more stable and are prepared for the next stage in reeling.

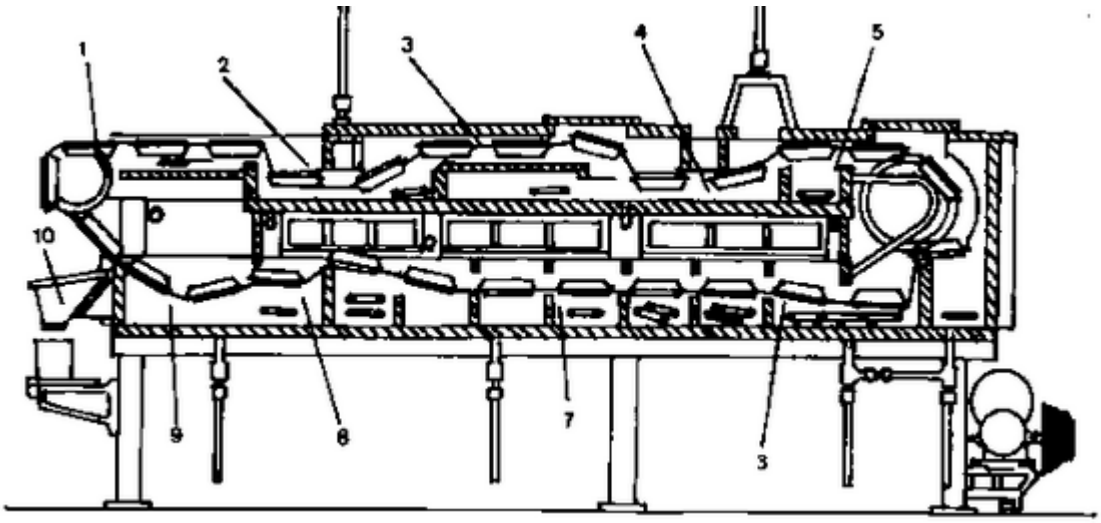


Figure 72: Cocoon Cooking Machine

1. Cocoon hopper part, 2. Soaking part, 3. High temperature permeating part, 4.low temperature permeating part, 5. Cooking part, 6-7. Adjusting part, 8-9. Low temperature finishing part, 10. Cocoon outlet

7.3 Brushing and methods of brushing

The cocoons brushed to remove the surface floss before reeling. Floss loosely knit, broken, uneven thickness, water silk. Without removing the floss layer one cannot reel the proper silk. This waste layer obstructs the reeling process unless it clearly removed. The process of removing floss layer called “brushing”

In open pan and three pan, cooking brushing combined with cooking. However, sunken system it done separately. After removing the floss layer, the ends of the cocoon thread picked up so that reeled can feed them for easy reeling.

The methods of brushing are;

1. Stick
2. .Hand Brush
3. .Mechanical Brush

1. Stick.

- A thin, single, flexible, soft stick used as brush

- The reeled holds the stick at one end and constantly stirs the other end in the cooking vessel/reeling basin.
- It is to collect the floss. When sufficient quantity of floss taken off from the cocoons the stick i lifted from the cocoons
- This process is to draw up the baves
- The stick is moved to sides by holding the collecting lump close to the cocoons
- The lump waste lifted about 25-30 cm up above the cocoons and the released baves caught and separated from the waste lump
- Cocoons with reel able ends transferred to the reeling basin.
- The waste lump further cleaned and dried. Sometimes instead of a single stick a prong made of two pieces is used
- This method useful when multi volatile cocoons handled. Because these possess much floss content
- It is not suitable for univoltine and bivoltine cocoons where amount of floss is comparatively.
- The stick brush used in the charka system and other older types of reeling systems
- It is called Ekkadi or Dokadi depending upon whether one or two sticks are used for collecting the floss

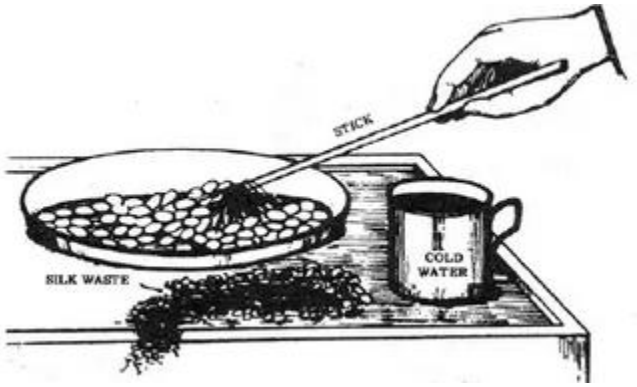


Figure 73: Brushing with stick

2. Hand Brush

- It made with flexible thick and long fibers tied like a broom
- It generally made from Khus-Khus grass (Vetiveria izaniodes) or paddy straw.

- The brush is 15-20cm long with a flat, circular brushing surface about 6-8cm in diameter
- The brushing process is more efficient and effective because of number of bristles
- There is no risk injury of bave or pupae.

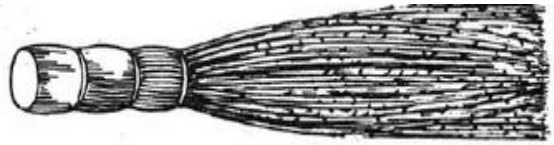


Figure 74: Hand brush

3. Mechanical Brushing

It is most suitable for filature reeling machines. After ladling the cocoons into the cooking vessel for a few minutes, the mechanical brush lowered into the basin. The brush makes clockwise and antilock wise rotary movements. After a definite number of movements (20-24) the brush lifted out of the basin either by cooking operative or automatically. It is important to maintain the required temperature of water

After brushing of cocoons, the operative carefully collects the teased, outer floss layer. Then all the baves drawn to unwind from the cocoon without any amount of floss.

The process is carried continuation with brushing and called as “cleaning the bave”. Generally, it done by the cooking operative. However, at sometimes it is carried in specially designed oval basin by separate basin in a wooden tub/perforate dipper/ladle with the bave ends of the cocoons twisted and tied to the hook.

Precautions in mechanical brushing are

1. Well sorted, uniform size and build cocoons are necessary.
2. Only one layer of the cocoons should be on the surface of water. Water level must be constant in such a way that cocoons should touch the brush for effective brushing

3. When the brush is lowered into the basin steam supply is stopped to avoid over-cooking
4. Brush must be clean and free from clogging
5. Unyielding cocoons returning from the reeling basin treated separately.

In multigene reeling basins, brushing unit provided for each reeling basin itself. The reeling basin suitably designed for brushing and reeling. This brush similar to automatic brush but is has a number of small brushes projecting from the main brush holder

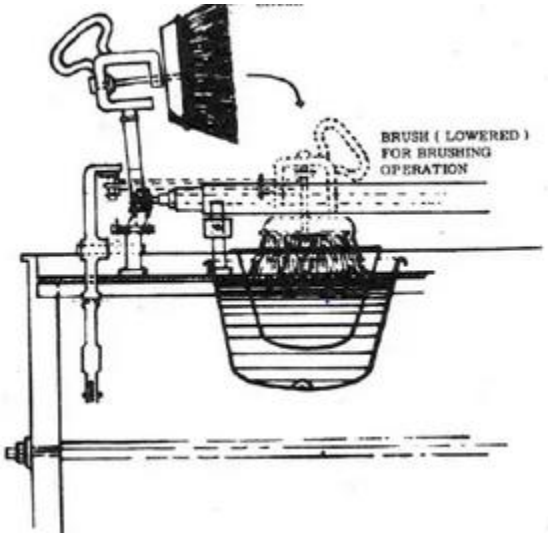


Figure 75: Mechanical Brushing

Central Cocoon Brushing Machine

It is specially designed brushing machine, which carries mass brushing of the cocoons. Designed for standardized brushing process and reduces percentage of waste. It saves labor because of mechanical and automatic brushing

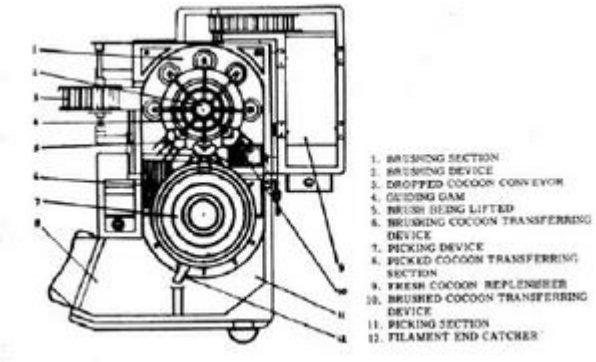


Figure 76: Central cocoon Brushing Machine

Information Sheet 8: Transferring cocoons to reeling basin with a perforated ladle

8.1 Transferring cocoons to reeling basin

The silk thread leaving coinsure surely contains considerable amount of water. This water makes the servicing wet and sticky. This kind of silk when wound on the reel defects of ribbing and plastering occurs. All these cumulative defects in the hank spoil the winding quality and silk wastage. Therefore needs to avoid defects of ribbing and plastering, which hamper the cost of silk

Various attempts made to avoid these defects. The electrically heated long shaft, to increase the length of the silk path between the closure and the reel. This process ultimately withdrawn because quick drying on hot surfaces spoils the strength and luster of the silk.

Keeping in view of these defects, the standard reel modified. The reel with rounded reel bars found to give satisfactory results. These reels used in rewinding machine

8.2 Grant reeling

Each reel operates its own traverse mechanism consisting of a setoff gears with specific ratios between them. This makes to obtain the particular pattern and number of webs or diamonds across the face of the hank. This hank should be of international standard hank. This process of reeling this process of reeling is known as grant reeling. If there is no such mechanism, it causes much delay in the knotting operation when a thread breaks. This grants reeling technique adopted in direct reeling as in the re-reeling mechanism

Information Sheet 9: Carrying out Cleaning of boiled cocoon and doing spinning operation

9.1 Amelioration of Water for Reeling

In a silk reeling establishment large amount of water used for

- Cocoon cooking
- Silk reeling
- Re-reeling
- Used in the boiler
- About 15,000 gallons of water used to manufacture about1000kgs. of silk yarn
- Essential to select the quality of reeling water carefully as it has grave effects on the reeling efficiency.

The water used for silk reeling should be free from impurities as many animal fibers like silk have a decided tendency to fix any substance found in water. Such water alters the appearance of the fiber as its luster becomes dull and matte, thus reducing the quality of the silk, colored organic matter in suspension spoil the color and luster of the silk

The hardness of water affects essentially the surface characteristics of the raw silk color, luster softness etc. This is due to the fixative effect of the serein fiber on the salts
Silk reeled in hard water poses difficulty in dying since a greater quantity of soap is to use for degumming.

For the boiler require water which produces less scales. Water with a certain degree of hardness has a favorable action on the unwinding of the filament of the dry cocoon because of its greater solvent effect compared with that of soft water. Rainwater not considered suitable for reeling

9.2 Boiler Water

Water for use in the boilers, which provide steam for heating the reeling water, should be as little hard as possible and devoid of substances that may cause corrosion of the boilerplates

The water hardness should not exceed 5 PPM in terms of calcium carbonate. The use of hard water in the boiler, due to precipitation and deposition of dissolved minerals and salts, leads to the formation of scales on the inner walls of the boiler

9.3 Cocoon spinning process

The process for producing single yarn out of discontinuous filament of cocoon is known as Spinning. The process by which silkworm produce cocoons also spinning. Eri cocoons are spun since they are opening mouthed and not composed of continuous filament.

Figure 77: Cocoon spinning

Silk Spinning steps

Step 1: Ingredients and Equipment:

- Cocoons
- 1 teaspoon of Lye
- 1 teaspoon of Baking Soda
- Small/medium Pot, depending on how many cocoons to degum (preferably a non-reactive pot aluminum ones will turn black)

- Pencil or pen with a rounded end (optional)
- Bowl or any open container for water

Figure 78: Ingredients and Equipment

Step 2: Degumming

- Fill a pot with water about 3/4ths of the way
- Mix in the lye and the baking soda
- put the cocoons in the water and push them in until squeeze the air out
- Be sure to wash hands after wards, as the lye can be a mild irritant. (The lye used relatively safe and mild, and is used to soften dried fish and pork in native cuisine)
- Heat contents to almost the boiling point and then turn down the heat to low and leave it to simmer for 10 minutes. Keep the pot covered.
- Occasionally press down the cocoons with a spatula or some other utensil.
- After 10 minutes, turn off the heat and go do something else until the contents of the pot have cooled down completely.
- Leave it a bit longer if want

Figure 79: Degumming procedure

Step 3: The Washing

- Place the cocoons in a sieve and rinse under the tap
- Press down enough to squeeze the lye water out.
- BE GENTLE do not want the threads to all tangled with rough handling.
- Do not worry about getting it clean just yet.

- just want to wash out the lye so that it doesn't irritate skin
- In fact, a bit of gum probably helps with the spinning process. After rinsing, place the cocoons in a container of clean water
- Keeping them in the water will make it easier for you to get the cocoons out without too much tangling.

Figure 80: Drain cocoon in sieve. Rinse out the lye, pressing the cocoons down very gently

Figure 81: Place the cocoons in an open container with water

Step 4: The Spinning!

- Take one cocoon, squeeze out excess water
- Insert a pen or pencil inside the opening of the cocoon with the rounded end.

- From the bottom end of the cocoon, pinch a bit of the silk and pull downwards a couple of inches
- Spin between thumb and forefinger
- Pull another couple of inches and spin again
- Keep repeating this process until do not have any more cocoon left
- Hang the yarn somewhere to dry.


Figure 82: Get one cocoon out of the water Squeeze out the excess water


Figure 83: Find the opening. Insert pen through the opening

Figure 84: Hold the top of the cocoon to the pen with one hand, and pinch the end with the other hand and pull gently but firmly.

Figure 85: Pull to about a couple of inches Spin the threads together with thumb and index finger

Figure 86: Pull another couple of inches and spin

Step 5: Keep Spinning!

- Different silkworms will produce different amounts of silk
- The cocoons of the samia ricini have produced yarns varying from a yard to three yards.

Figure 87: Keep spinning the cocoon is reducing**.**

Figure 88: A little nub might remain at the end. 9' and 6"!

Information Sheet 10: Reeling filaments of 7-9 cocoons together

10. Introduction

Reeling is the last phase of sericulture, which is involved with technical industrial skills. The reeling process involves various stages or processes which finally judges the quality of silk. In Indian villages even today charka reeling is found in many units which is economical for a small scale reel

In general, silk reeling defined as unwinding of silk cocoon. However, it technically defined as the process of finding the right end of the cocoon filament and jointly taking several ends together to reel raw silk. These processes carried using reeling machines, which operated by skilled person who technically known as reeled

The reeling process carried in two ways

1. Direct reeling on standard reels
2. Indirect reeling includes preliminary reeling on small sized reels and transferring the reeled silk from the reels to standard sized reels on re-reeling machines

In any case, the temperature of water in the reeling machines should be at optimum level to suit the reeling appliances, nature of water and condition of cocoons. Brushed cocoons with their filaments supplied to the reeled for reeling.

10.2 Silk reeling

Silk reeling is the process by which a number of cocoon baves are reeled together to produce a single thread. This 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.

The technique of raw silk making discovered several million years ago. The cocoons softened using hot water and the silk filament drawn continuously. This uniform thick and strong thread used for the manufacturing of fine silk fabrics. Silk reeling the final and purely commercial phase of sericulture. It is concerned with unwinding of the silk filaments of the cocoon

The term raw silk (Grege) in industry or commerce commonly understood to denote mulberry raw silk. It the compact untwisted and un-degummed silk thread that formed by combining the required number of silk filaments drawn from as many separate cocoons by a special technique called Reeling

This includes a series of skilled operations to transform raw material (cocoons) into a fine, continuous silk filament of great length. Unlike other aspects of sericulture, reeling needs constant attention and care, since the process of reeling the cocoon filaments break continually and reeler must properly attach fresh filaments to make a continuous filament. If not, the reeled silk results in the abrupt occurrence of thin

Raw silk reeling classified by

- Direct reeling method on a standard sized reel
- Indirect method of reeling on small reels
- The transfer of reeled silk from small reels onto standard sized reels on a re-reeling machine. The last technique primarily applied in modern silk reeling processes.

10.3 Silk reeling devices

There are many types of silk reeling machines in use.

The major structural features of the Sitting Type Reeling Machine, the Multiends Reeling Machine and the Automatic Reeling Machine

1. Hand spinning wheel

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

2. Charka Type reeling machine

The Charka type is in use in India. The machine 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 (see Appendix, Figure 17). The motor-driven reeling machine is not equipped with the stop motion attachment (see appendix, Figure 18). There are obstacles to the production of good quality raw silk as the raw silk thread wound too rapidly to maintain good quality control.

4. Multi-ends reeling machine

This machine eliminates the disadvantages of the Sitting type reeling machine by increasing the number of reeling thread ends per basin and reducing the reeling speed. The operator must stand when running this machine as the number of reeling threads per basin increases by twenty-fold. This is also called a "Standing type reeling machine". Reeling efficiency is unchanged. Quality is better due to reduced speed.

The Multiends reeling machine is composed of driving part, groping ends, picking ends, standby bath, reeling part, jetboute, stop motion, traverse guider, small reels, steam heating pipes and clutches (see Appendix, Figure 19).

The cooked cocoons contained in the tubs carried into the groping ends portion of the reeling machine. From there, cocoons moved into the picking ends apparatus. After correctly processing, the cocoons go to the standby bath for cocoon feeding. They picked up by the reeler and fed to the reeling thread. During this step, a number of cocoons dropped thus reducing the ratio of reeling cocoons per thread. The normal speed of cocoon feeding by a skilled reeler is around 16 times per minute. The reeling thread passes through the jetboute, silk button, first guider, second guider, third guider, fourth guider, traverse guider, in that order and then is wound onto the small reels.

The cocoons dropped during the reeling process gathered and reprocessed starting from the groping end section. The coinsure of reeling thread made between second guider and third guider, and the length of croissure is not for twisting of thread but for cohesion of thread by rubbing of composed filament. Typically, one set of Multi-ends reeling machines consists of ten basins with each basin having twenty ends or reels.

Basin: The basin is rectangular with well-rounded corners and edges. It is only 10 to 12 cm deep. It is commonly made of dark colored porcelain. The basin subdivided into sections, each intended for a specific job such as brushing, end gathering of baves, stocks in reserve and waste collection.

Reels: The reels of the Multi-ends reeling machine have a circumference of 75 cm. The frame of the reel is made of light metal or plastic. The reels fitted into reel carriers and driven by a transmission shaft by connecting gears.

Traverse guider*:* To ensure narrow and long web on the hank of the reel, a can type traverse assembly fixed. This will make a convex surface in the hank, which wound on the reel. The centre part of the hank is higher than the two axis.

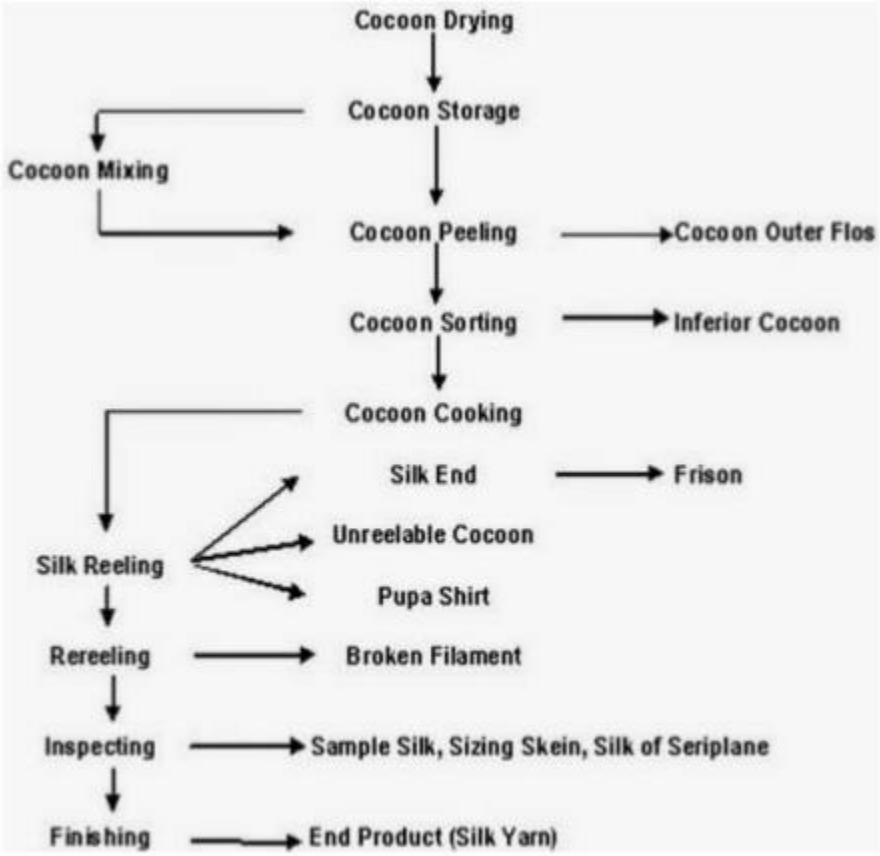
Thread button: Porcelain button thread-guiders used for removing any dirt adhering to the thread passing through the tiny aperture in the button.

5. Automatic reeling machine

In raw silk production, the continuing increase of labor costs has mandated automation. Around 1950, the Automatic reeling machine, which controls the number of reeling cocoons per thread, invented. Shortly thereafter, it replaced by a second Automatic reeling machine, which could automatically control the size of the reeling thread.

The Automatic reeling machine mechanizes the processes of groping ends, picking ends; cocoon feeding to reeling thread and separation of dropped end cocoons during the reeling process. The efficiency of the Automatic reeling machine compares favourable with the manual Mult-ends reeling machine.

The Automatic reeling machine though built to replace manual reeling, still requires manpower for problems with the reeling thread, which must be corrected by hand. A moderate amount of cooked cocoons are carried to the newly cooked cocoon feeder (3) and then removed into the groping end part (4)


Cocoon Drying
Cocoon Storage
Cocoon Mixing
Cocoon Peeling
Cocoon Outer Flos
Cocoon Sorting
Inferior Cocoon
Cocoon Cooking
Silk End
Frison
Unreelable Cocoon
Silk Reeling
Pupa Shirt
Rereeling
Broken Filament
Inspecting
Sample Silk, Sizing Skein, Silk of Seriplane
Finishing
End Product (Silk Yarn)

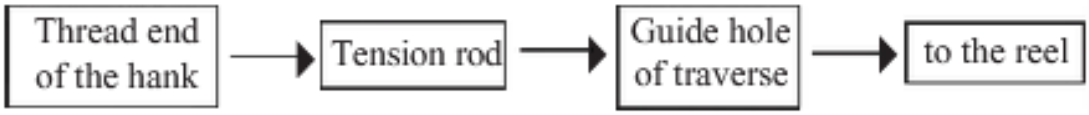
Information Sheet 11: Doing re-reeling of reeled thread

11.1 Re-reeling

The re-reeling operation is simple and silken jog. The direct reeled silk hank gummed threads at the reel points loosened and placed over the swift. Wetting agents used to soften the gummed threads. The thread end from the outer surface of the hank taken over the tension rod and through the guide whole of the traverse and attached to the reel.

The reels begin to revolve when brake released where the thread from the hank pulled and unwound to wind on the reels of the re-reeling machine. During the process of re-reeling thread, breaks occur at a weak spot, as it cannot withstand the tension. Then the operative removes the length of thin thread from the hand on the swift before uniting the broken ends and re-starting the rewinding operation

11.2 Re-reeling process



Re-reeling machine used for rewinding the silk from small reels almost similar to the machine explained earlier. This machine lacks swift rack and the silk reeled off by placing the reels on the ground. The reels wetted by water or mild wetting agents before re-reeling. In any case re-reeling is the process which facilities the packing, where direct reeled silk is wound on to a standard reel (1.5 mts. In circumstance) to make skeins of a certain length, width and weight. The weight of the skein generally kept at 70 gms. Upto 33d, and 140 gms above 34-denier raw silk.

Re-reeling is a process of reeling the raw silk from small reels onto large (standard) reels with a circumference of 150 cm, adjusting the width and weight of skein uniformly. The object of re-reeling is to make standard sized hanks or skeins for marketing purposes. Skeins should have a circumference of 150 cm in accordance with

International Standards. Secondly, re-reeling eliminates defects, which might have occurred during reeling.

11.3 Re-reeling machine and apparatus

The re-reeling machine consists of various parts and instruments such as the grand reel, reel revolution and stop motion equipment, traverse bar and guider and drying pipe, double thread checker and accessory utensil (see Appendix, Figure 24). The circumference of the grand reel is 1,50 cm and length of the reel rib to be used for five skeins is usually 0.67 meters.

How to re-reel raw silk

1. Pre-treatment

To obtain best results from the re-reeling process, the serein gummed at the rib edge of the small reel swollen and softened through a dipping process.

I. **Infiltration method** by vacuum tank 203 times infiltration with 30-35° C water under 40-60 cm Hg recommended (see Appendix, Figure 23).
II. **Bath method.** Dipping time normally 10-30 minutes, but should be changed depending upon the temperature and concentration of the chemicals used. Currently emulsified oil recommended for use as a chemical for re-reeling.
III. **Damping method.** It is sometimes desirable that the hard-gummed raw silk on the small reel covered with a wet cloth.

2. Dipping during the re-reeling process

In the case of a double skein, additional water occasionally needed when there has been inadequate wetting of the raw silk on the small reel. This accomplished by use of water spray, dipping and wet cloth, for instance.

3) Re-reeling process

There is a tendency that re-reeling velocity closely related to the number of breaks of the raw silk, re-reeling efficiency and generation of the gummed skein. Optimum velocity recommended for re-reeling is 150-170 rev. /min. for 21-denier and 130-160 rev. /min.

for 14-denier raw silk. The best temperature and relative humidity of re-reeling is around 41° C, 36 percent R.H. Under this condition the moisture content of raw silk skein immediately after re-reeling reaches 6.2 percent and the raw silk skeins are not stuck together

Temperature and humidity of re-reeling in the machine

Temperature (° C)	Relative humidity	Moisture content of raw silk skein after re-reeling (%)	Appearance of raw silk skein
31 41 68	55 36 29	9.7 6.2 2.7	Gummed Normal Over dried

Raw silk should have about 6-8 percent moisture in it after the re-reeling process is finished. The number of grand reels per labourer should be around 15-20 grand reels for 21-denier and 20 grand reels for 14-denier. This will change if the raw silk size, re-reeling velocity and number of thread breaks are not within expected bounds.

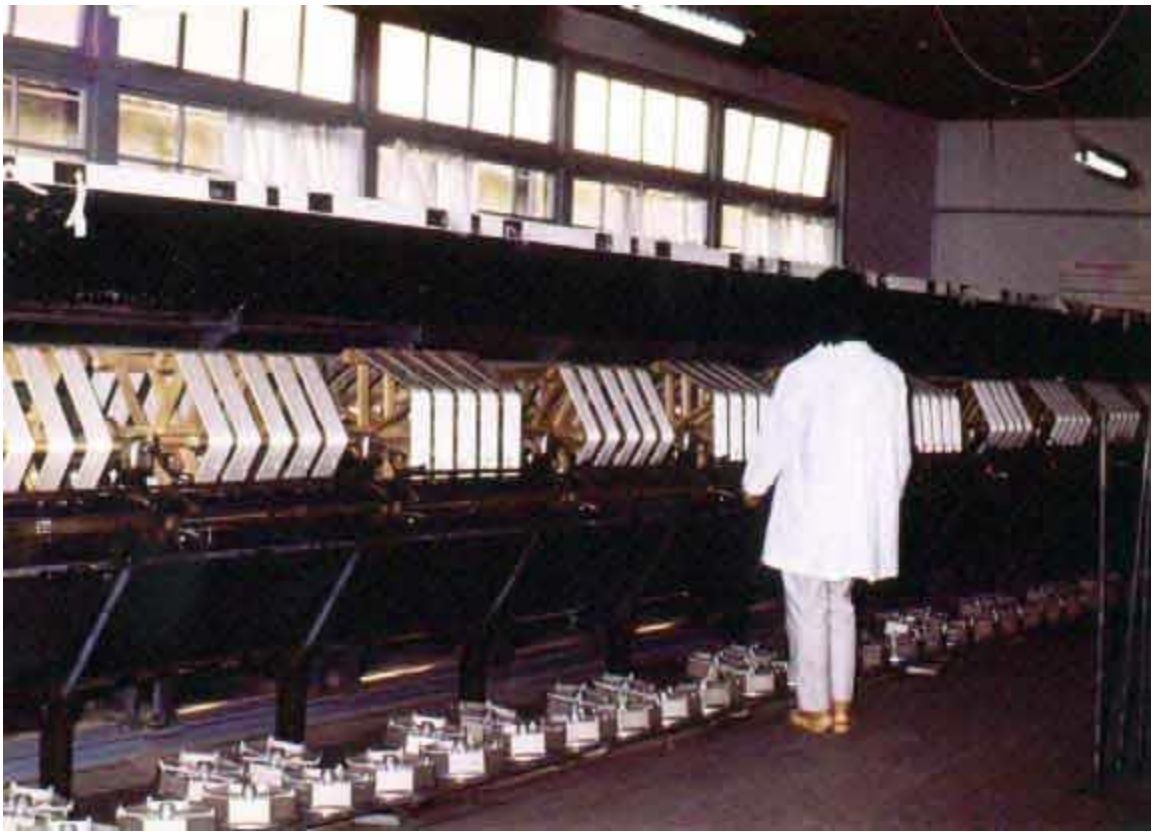


Figure 89: Raw silk re-reeling machine

REREELING

It is to transfer the raw silk reeled on small reels to a large reel 91.5m circumference) to set uniform width, weight and length of the skein.

Purpose:

- To eliminate gum spots in the reeled silk
- To tie up any loose ends to form continuous silk thread.
- To ensure smooth and efficient operation during the winding process

Information Sheet 12: Doing testing and grading operations

12.1 Testing and grading operations

Silk weaving has reached a very high standard of industrial efficiency. In fact, today a number of varieties of silk fabrics produced on handlooms and sophisticated power looms. This requires different qualities of raw silk. In order to assist the weaving industry in the selection of the required raw silk, it must be first tested and classified. Further, the raw silk reeling industry requires well-defined standards, which can only achieved by silk testing.

As the demand for silk is global and a number of countries compete in the trade of raw silk, it is necessary that there should be industry standards for raw silk quality enable buyers to purchase raw silk at internationally accepted grades. This is the reason why all raw silk produced should be classified following testing.

The testing of raw silk based on the procedure laid down by the International Silk Association (I.S.A.). This procedure quite conservative and the equipment used consistent with traditional patterns when compared to procedures followed for general textile products. The traditional method has been widely preferred in silk producing and consuming countries of the world.

The mechanical testing procedure similar everywhere, but the compilation of test results and standards for various grades differs slightly from country to country.

Two main tests are

- Conditioned weight test
- Test for quality

12.2 Conditioned weight test

The quantity tested from a consignment depends on the

- Total weight. Usually, 5-10 bales of 60 kg each
- Total weight 20 bales of 30 kg each the unit of testing used for the export of raw silk.

12.3 Quality test

a. Visual Inspection

- Conducted on the whole lot of raw silk, which has classified
- carried out in an inspection room, which is well illuminated
- There are three main factors that have to be tested

1. Uniformity

In this test, the entire lot inspected to assess the uniformity of color, luster and feel. The result not recorded in the I.S.A. method, but classified as good, fair and inferior under the Japanese method.

2. General finish

Here, considering the presence and degree of a number of defects assesses the general finish of the lot. These defects are:

I. Re-reeling. Gummed skeins; gummed spots on skeins; double ends; irregular traverse and partial flack of traverse.

II. **Finish.** Tangled filament, defective lacing, filament out of place in skein (pulled filaments loose).

III. Arrangement. Lacing of booking card through skeins; non-uniform skeins; wrong twisting; raised filament; streaky filament; cut ends; dis-colored skeins; foreign matter on skeins; irregular skeins on book; knots on skeins; skeins or books of different types.

IV. Damage. Books of irregular shape; gummed books, soiled filaments; frayed skeins; insect attached skeins; musty skeins, etc. The results expressed in terms such as good, fair, poor or inferior. Outstanding defects mentioned in the Test Certificate

3. Nature

The degrees of Color and Luster and the Smoothness or Hand of the lot inspected and indicated in the following manner:

i. Color: light, medium or deep
ii. Luster : bright, medium or dull

iii. Hand : smooth, medium or rough

b. Sample test

After completion of the test overall lot, the following tests have to be conducted. To conduct these tests, it is necessary to take out 50 skeins off the lot if the skeins weigh below 120 g. alternatively, 25 skeins taken if the skeins weight over 120 g. Having extracted the required number of skeins, the following test carried out:

1. Winding test

Equipment required:

- Winding frame
- Wheels and bobbins

Number of sample skeins drawn out for this test should be 40 skeins out of 50 skeins for a lot which weighs approximately 70 g each and 20 skeins out of 25 skeins drawn out for each skein weighing approximately 140 g.

When winding started, only the top half of the sample skeins wound.

The winding carried out at a predetermined speed for a specific duration. The number of breaks that occur counted and noted. When breaks occur, it is necessary to note the cause of each break and this recorded.

Average speed and winding period for winding test

Size under test	Preliminary winding	Average speed (meter/min.)	Winding period (minutes)
		70 g skeins	140 g skeins
12 denier or finer	10	110	60
13-18	10	140	60
19-33	10	165	60
34-69	5	165	30
70 or coarse	5	165	20

The winding speed and duration of winding has also to adjust according to the denier of the raw silk tested. For reference purposes, the different time and speed and other requirements

2. Size deviation test

Equipment required:

- Sizing reel (1:125 meters in circumference)

- Balance
- Denier scale

Only a fixed length from each skein taken for the testing. The highest degree of deviation noted and compared with the average size deviation of the conditioned weight. When testing raw silk of 33-denier or finer in size, 200 skeins of 450 meters each taken out by picking out four skeins out of each of the 50 sampling skeins taken from the testing lot. In the case of 34-denier and over, 400 sizing skeins are extracted by picking eight skeins of 112.5 meters in length each from the 50 sample skeins (total length 45 000 metres).

3. Evenness test

The test is carried out with test samples of a fixed length using a Seriplane. These test samples represent fine passages and coarse ones, divided into 3 groups (Evenness Variation, **I, II** and **III**) according to the degree and fequency of size variations.

4. Cleanness test

This test is conducted to ascertain Super Major Defects, Major Defects and Minor Defects. Each defect carries penalty points and the difference of the total penalty points from 100 gives the test result.

Definitions

Cleanness Defects These are categorized into three general groups, viz., Super Major Defects, Major Defects and Minor Defects

Super Major Defects: All major defects in length or size which are ten times larger than the minimum size of Major Defects are named Super Major Defects.

Major Defects: These are divided into five as follows:

5. Neatness test

Neatness defects : Imperfection in raw silk yarn, which are smaller than those described as minor cleanness defects are known as neatness defects. Nibs are small thickened places or spots in the yarn less than 2 mm in length. Loops are small open places in the yarn caused by the excessive length of one or more cocoon filaments, less than 10 mm in length when measured along the filament. Hairiness and fuzziness are the conditions

of yarn, which show small loose ends of less than 10 mm and fine particles of cocoon filaments protruding from the yarn. Small knots are knots, which have loose ends, less than 3 mm in length. Fine corkscrews are places in which one or more cocoon filaments are longer than the remainder and give the appearance of a spiral.

6. Tenacity and elongation test

To test the strength of the raw silk, the breaking point (g per denier) and the degree of elongation (percentage) is carried out on the Serigraph. This test is conducted in a room, which is maintained at a standard temperature of 20ºC and a humidity of 65 percent.

7. Cohesion test

By means of the Duplan cohesion tester, the number of frictions required to split silk thread for the purpose of examining the state of cocoon filaments sticking together, can be counted. This test is conducted in a room kept at standard temperature and humidity.

c. Quantitative test

Conditioned weight test

When weighing the gross weight and the dried weight of raw silk, the conditioned weight is calculated by adding 11 percent (International Standard Regain) to the dried weight.

The conditioned weight of raw silk is obtained as follows:

All skeins of raw silk for the test are put into a room with a constant temperature and humidity for 12 hours. 20 skeins are picked up for a test unit and are then weighed separately as the original weight.

Two skeins are selected from the sample for the conditioned weight test.

The sample skeins are dried in an oven one by one with the drying temperature at 140ºC. The drying is continued until the different at every weighing (every 5 minutes) is within 0.1 g.

Moisture regain is calculated as follows:

Raw silk classification

Grades

For classification purposes, raw silk is divided into three categories according to their sizes:

1st category: 18 denier and below

2nd. category: 19 to 33 denier

3rd. category: 34 denier and above

The grades are expressed in the following order in all categories of raw silk:
4A, 3A, 2A, A, B, in I.S.A. Standard (Table 38-1, 2,3)
and 5A, 4A, 3A, 2A, A, B, C, D in Japanese method (Table 40-1, 2,3)

Cocoon grades by visual inspection

Information Sheet 13: Doing lacing

13.1 Lacing

In this process the two ends of the silk hank are tied with coloured thread. To keep the diamond pattern of the hank from disc leveling threadsof different colour are laced in between to keep the hank in position. Lacingis a process in which a thread passing across the hank in such a way so as todevide it into five equal parts. So that the threads are kept in place to ensurethat the thread can be unwound easily. Unlaced silk has threads in anentargled manner, which results in breaks and finally wastage of silk. Lacing is done with silk or cotton thread which can be snapped or broken easily by hand (Fig. 4.15). generally coloured silk thread is used for securing theends and white thread for the lacings. For differenciating different denier of silk different coloured threads are used.

13.2 Silk end tying and skein lacing

The tie end of the raw silk tied with cotton year, to find the silk thread end easily during the preparation process for weaving. This known as silk end tying. Skein lacing keeps the diamond cross originally in the skein place. Five interlacing's each at three places on the skein are suitable to prevent tangling

Lacing of silk skeins

Information Sheet 14: Carrying out skein

14.1. Skinning

The skinning prevents ruffling and further entanglement of filaments during packing. After cleaning and lacing, the raw silk skein. It done by twisting hank several times and folding upon itself number of spirals. in such a manner the silk threads in the hank do not get ruffled or entangled of the silk subsequent process of booking bundling and general handling of the silk until it is opened for use in the twisted operation. The skinning process carried by a separate set of operatives using skinning machine or a turner

In skin, making one end of the laced hank carefully passed over short brass tube held in the palm of the operative. Then operative gives several turns to the handle by holding the silk hank tightly. Further the operative places his fingers at the center of the twisted hank and folds the hank upon itself. Because of the twisting given previously, the hank when folded turns by itself in spirals

After unhooking the hank from the skinning machine and slips through the loop the other end of the hank held in the palm. Thus, the endemerging from the loop opened out and extended into a circle which isknown as the flower or fiacco crown. This structure protrudes about 1.5 to2 cm above the loop.

The silk thread of the loop are carefully spread out ina fascia about 5 cm wide. The standard loop possess five district spirals, aloop and fiacco (Fig. 7.19). This skin inserted with a slip of paper bear-ing the number of the basin.

14.1 Standard of Skein

The International Standard Skein should be 148-150 cm (58”-59”) in circumstances with ribbing not more than 2cm at any one of thesix ribs. It may have 8-13 diamonds across the face of the 7.5 cmwide hank. It should be without hard gum spots and weight be-tween 65-70 gm. Upto 12 denier, 70-85 gm, upto 24 denier, 80-90gm upto 32 denier and 90-100gm above 32 denier

Information Sheet 15: Doing book making and bailing to transport

15.1 Book making and bailing

All the skeins made into books and bailed. The skeins made into neat books of approximately equal weight and dimensions in a book-making machine. In each book, there are eight skeins in the horizontal row and five in the vertical row. These books neatly tied with separate cotton bands at three places and wrapped in tissue paper.

The books further wrapped in thin cotton cloth first and later in Hessian cloth. These packed details about the number of skeins in a book, with their denier are marked for marketing.

15.2 Booking and packing

In order to provide proper moisture to the raw silk, the skein kept between 20-23° C and 65 to 75 percent relative humidity for several hours prior to booking of the skein.

15.3 Standard of skein size:

There are two standard skeins, the 70g known as a single skein and the 125-135g size known as a double skein. The double skein is the preferred version.

15.4 Booking of the skeins

With the bleached cotton rope doubled with 74 plies of 10s yearn; the 30 skeins must be bundled into a book if they are single skeins (5 line 6 stairs). In the case of double skeins, a book consists of 20 skeins.

15.5 Packing of a lot

One bale contains 22-30 books and the standard weight is about 60 kg.

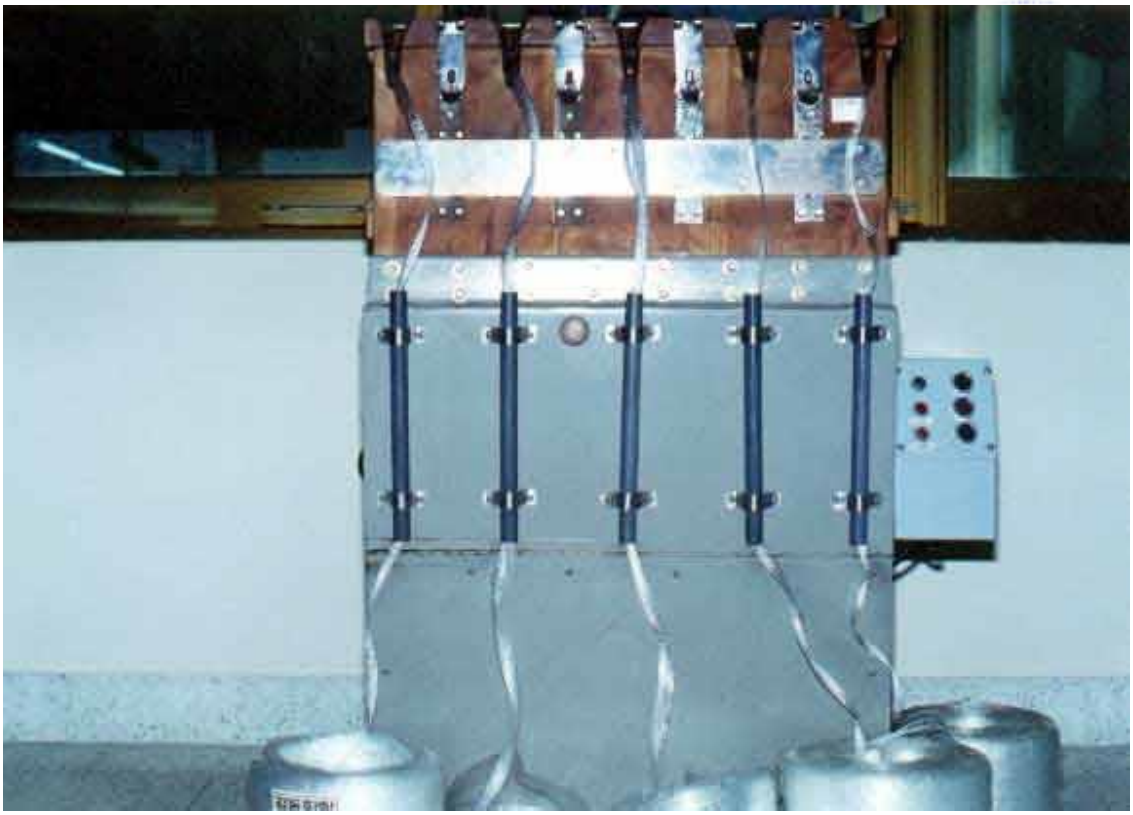


Figure 90: Booking appliance of silk skeins

L #77	LO #5 Report silkworm feeds plant and treat silkworm disease, pests and predators

Instruction sheet

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Recognizing feed plant pests, diseases and disorders
- Recording and reporting details of silkworm and silkworm plant disease.
- Recognizing egg, larvae, pupae and moth pests and diseases by common name
- Selecting treatment methods for silkworm and silkworm plant disease

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Recognize feed plant pests, diseases and disorders
- Record and report details of silkworm and silkworm plant disease.
- Recognize egg, larvae, pupae and moth pests and diseases by common name
- Select treatment methods for silkworm and silkworm plant disease

Learning Instructions:

Read the specific objectives of this Learning Guide.

1. Follow the instructions described below.
2. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them
3. Accomplish the “Self-checks” which are placed following all information sheets.
4. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks)
5. If you earned a satisfactory evaluation proceed to “Operation sheets
6. Perform “the Learning activity performance test” which is placed following “Operation sheets”
7. If your performance is satisfactory proceed to the next learning guide,
8. If your performance is unsatisfactory, see your trainer for further instructions or go back to “Operation sheets”.

Information Sheet 1: Recognizing feed plant pests, diseases and disorders

1.1 Mulberry plant disease

1.1.1 Powdery mildew

Due to fungus phyllactinia corylea causing yellow brown patches on the lower surface of leaves.

Figure 91: Powdery mildew

1.1.2 Leaf spots

Due to fungus, cercospora moricola causing circular brownish black spots on the leaves.

Figure 92: Leaf spots

1.2 Castor: Diseases and Symptoms

1. Seedling blight

Disease symptoms: Dead seedling

- The disease first makes its appearance on both the surfaces of the cotyledonary leaves in the form of roundish patch of dull green colour which soon spreads to the point of attachment causing the leaf to rot and hang down
- **Spots on older leaf**

Figure 93: Spot on older leaf Leaf symptom

- The infection further spreads to the stem with the result that the seedling is killed either due to the destruction of growing point or by the collapse of stem.
- The true leaves of seedlings and the very young leaves of older plants may also be affected; but ordinarily not much injury is caused
- The leaf spots turn yellow and then brown and concentric zones of lighter and darker brown colour are formed.
- The disease spots coalesce at a later stage and cover almost the entire leaf.
- The affected leaves shed prematurely. Under moist conditions, a very fi ne whitish haze is found on the under-surface of the leaf spots.

Survival and spread:

- The pathogen survives in soil or collateral or alternative hosts.

Favourable conditions

- High humidity and warm conditions favor the development of disease.

2. Alternaria blight

Disease symptoms: Alternaria leaf spot with concentric rings

Figure 94: Alternaria leaf spot with concentric rings

- All the aerial parts of the plant, i.e., stem, leaves, inflorescence and capsules are liable to be attacked.
- These may appear on any portion of the leaf and are irregular, scattered, and have concentric rings.
- These are brown and later become covered with bluish-green or sooty growth
- When the attack is severe the spots coalesce and form big patches resulting in premature defoliation of the plant which gradually wilts away
- In one case the capsules, when half mature, wilt suddenly, turn brown and due to collapse of the pedicel the capsules fall or hand down.
- They are smaller in size and have under-developed and wrinkled seeds with little oil content.

Survival and spread

- Fungus is seed borne and survives in seeds

Favourable conditions

- High humidity and low temperature (16-20 ºC) favours the development of diseases.

3. Cercospora leaf spot

Disease symptoms:

Figure 95: Cercospora spots on leaf

- The disease appears as minute black or brown points surrounded by a pale green ring
- These spots are visible on both the surfaces of the leaf.
- As the spots enlarge, the centre turns pale brown and then greyish-white surrounded by a deep brown band which may be narrow and sharp or broad and diff used
- The fructifications of the fungus appear as tiny black dots in the white centre.
- The diseased spots often occur in great numbers scattered over the leaf and are roundish when young but may become irregularly angular when mature
- When the spots are close together, the intervening leaf tissue withers and large brown patches of dried leaf may result.

Survival and spread:

- The fungus survives in soil debris which is cause of primary infection. Secondary infection occurs by conidia through rain splash or wind.

Favourable conditions:

- High humidity and warm weather conditions responsible for the disease.

4. Powdery mildew

Disease symptoms: Powdery mass covering entire leaf

- It characterized by typical mildew growth, which generally confined to the under-surface of the leaf.
- When the infection is severe, the upper-surface also covered by the whitish growth of the fungus.

- Light green patches, corresponding to the diseased areas on the under surface, are visible on the upper side especially when the leaves are held against light.

Survival and spread:

- The pathogen survives as oospores on the affected plant tissues and on weed hosts.

Favourable conditions:

- Cool (10-20º C) and wet weather (90% RH) favours disease development

5. Wilt

Disease symptoms

Figure 96: Wilt affected castor field

- Leaves droop and drop off leaving behind only top leaves
- Diseased plants are sickly in appearance
- Wilting of plants, root degeneration, collar rot, drooping of leaves and necrosis of affected tissue and finally leading to death of plants.
- Necrosis of leaves starts from margins spreading to interveinal areas and fi nally to the whole leaf.
- Spilt open stem shows brownish discolouration and white cottony growth of mycelia much prominently in the pith of the stem.

Survival and spread:

- The fungus is soil-borne and remains in the soil as saprophyte for 2-3 years. The disease primarily transmitted through infected seed pieces.
- The secondary spread aided by wind, rain and irrigation water.

Favourable conditions:

- High day temperature (30-35˚C).
- Low humidity (50-60%). Low soil moisture and alkaline soils.

1.3 Pest of castor plant

1. Red hairy caterpillar *Amsactaalbistriga, A. mooreii*

Symptoms of damage:

- These hairy caterpillars scrap the under surface of the leaf when they are in neonate stage
- Later the scrapped patches of the leaves looks like thin papery
- Fully grown larvae devour the entire foliage, flowers and growing points

Identification of the pest:

- **Larvae:** hairy caterpillar reddish brown with black band on either end having long reddish brown hairs all over the body
- **Adult:** moth with white wings

Amsacta albistriga:

- **Forewing-** white with brownish streak all over and yellowish streak along the anterior margin and head
- **Hind wing-** white with black markings

Amsacta moorei:

- **Forewing -** white with brownish streak all over and reddish streak along the anterior margin and head

Management:

- Collection and destruction of egg masses and hand picking of larvae
- The barnyard millet (*Echinochloea frumentacea*) may act as strong barrier
- Summer ploughing and poison baiting
- Erection of light traps soon after the monsoon for 20-45 days, collecting and killing of adult moths are found to be very effective
- The dispersing larvae of hairy caterpillar from one field to another can be checked by digging trenches across the direction of their march, and prompt destruction of larvae

- Vegetative traps utilizing Jatropha (wild castor) or Ipomea prevent the migration of the grown up larvae
- Prepare small balls with10 kg rice bran+1 kg jaggery+1 liter quinolphos broad-cost in the fields preferably in the evening times
- Dusting of carbaryl or quinolphos @ 25-30 kg/ha would be effective in the control of young larvae
- Use of 200 ml dichlorovos 100 EC dissolved in 400 litres of water/ha may be used to control grown up caterpillars
- Spray QuinalPhos or dimethoate 2ml, 2 ml/lit of water

Figure 97: Red hairy caterpillar

2. Tobacco caterpillar *Spodoptera litura*

Symptoms of damage:

- The early instar larvae feed gregariously on the under surface of the leaf leading to skeletonization of the leaves
- Sometimes the feeding is so heavy that only petioles and branches left behind. In case of severe attack cause complete defoliation

dentification of the pest:

- **Egg:** Egg masses appear golden brown
- **Larva:** Pale greenish with dark markings, gregarious in the early stages

- **Adult:** Forewings are brown colour with wavy white markings, Hind wings- white colour with a brown patch along the margin

Management:

- Collect and destroy the egg masses and caterpillars in the early stages of infestation
- Plough the field so as to expose the pupae to predators and parasitoids
- Monitoring the pest with pheromone traps (4-5/acre) helps in timely treatment
- To control early stage larvae, spray neem seed kernel extract (NSKE) 5% or chlorpyriphos 2.5ml 2ml or quinolphos 2ml or neem oil 5ml/ litre of water
- As the grown up larvae move down to soil to hide during day time, poison bait (1 litre of 1kg carbaryl+10kg of rice bran+1 kg jaggery+1 litre of water to make the bait in to pellets for one hectare) placement at base of the plants helps in killing the larva

Figure 98: Tobacco caterpillar

3. ihar Hairy Caterpillar *Spilosom aobliqua*

Symptoms of damage:

- Young larvae feed gregariously mostly on the under surface of the leaves
- A caterpillar of later stages defoliates the field completely

Identification of the pest:

- **Egg:** Laid in clusters of 50-100 on the lower side of leaves
- **Larvae:** Orange coloured with broad transverse band with tufts of yellow hairs that are dark at both ends

- **Pupa:** Forms a thin silken cocoon by interwoven shed hairs of the larvae
- **Adult:** Crimson coloured moth with black dots and a red abdomen. Wings are pinkish with numerous black spots

Management:

- Collection and destruction of eggs and early stage larvae
- Spray NSKE 5% to kill early stage larvae
- If grownup larvae are seen, spray quinalphos, chlorpyriphos @ 2ml/litre of water

4. Capsule Borer: *Conogethes (=Dichocrosis) punctiferalis*

Symptoms of damage

- Capsule with bore holes
- Damaged capsules webbed together
- Peduncle and capsules showing galleries made of silk and frass

Identification of the pest

- **Larva:** pale greenish with pinkish tinge and fine hairs with dark head and prothoracic shield
- **Adult**: yellowish with black spot

Management

- Spray any one of the following insecticides, thrice from flowering at three weeks interval
    - Malathion 50 EC 2.0 l/ha
    - Carbaryl 50 WP 2.0 kg/ha in 1000 l of water





Figure 99: Capsule Borer**:**

5. Jassids*: Empoasca flavescens*

Symptoms of damage:

- Leaf margins become yellow
- Curling of leaf edges and leaves turn red or brown
- Leaves dry up and shed

dentification of the pest:

- **Nymph**: green coloured
- **Adult**: green wedge shaped insect

Management:

- Seed treatment with imidacloprid or carbosulfan protects the crop from all sucking pests including jassids for about a month.
- Spray dimethoate (0.05%). Repeat spray if required after a fortnight.

Figure 100: Jassids

6. White flies *Trialeurodes ricini*

Symptoms of damage:

- Water soaked spots on the leaves which become yellow and dry up
- Leaves appear sickly and get coated with sooty mould
- Stunted plant growth, shedding of fruiting bodies

Identification of the pest:

- **Nymph**: yellowish

Management

- Whiteflies can be effectively attracted and controlled by yellow sticky traps, which are coated with grease/sticky oily materials

- Spray triazophos (2.5 ml/l) or acephate (2 ml/l)
- Spraying of any neem product (Neem oil 3% or NSKE 5%) with any sticky material

Figure 101: White flies

7. Thrips Retithrips siriacus: Scirtothrips dorsalis

Symptoms of damage:

- Terminal leaves silvered
- The injury results in development of dull yellowish-green patches on the upper leaf surface and brown necrotic areas of the lower surface
- Under heavy infestation the leaves curl and plants get stunted

Identification of the pest:

- **Nymph:** Pinkish (*Retithrips siriacus*); yellowish (*Scirtothrips dorsalis)*
- **Adult**: Black with fringed wings

Management:

- Insecticides such as dimethoate, methyl-o-demeton at the rate of 2.0 ml/litre of water give control of thrips effectively

Figure 102: Thrips retithrips siriacus

1.4 Insect pest

The plants attached by some insect pest like

- Leaf eating caterpillar (Dircrisia oblique)
- Jassid (Empoasca flavescens)
- Mealy bug (maconellicoccus hirsutus),
- Scale insects
- Thrips
- Stemgirdler beetle (sthenia grisator)
- Powder pestbeetle (sinaxylon pubens)

Self-Check-1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Fill the blank space

1. Write the fungus disease of mulberry plant. (2%)

_____,_____

2. List down mulberry plant insect pest (4%)

_____,_____

_____,_____

_____,_____

_____,_____

3. Write the castor plant disease (4%)

_____,_____

_____,_____

_____,_____

4. Write the pest of castor (5%)

_____,_____

_____,_____

_____,_____

_____,_____

Answer the following question!

Note: **Satisfactory rating 8 and 15 points Unsatisfactory 8 below and 15 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = _____

Information Sheet 2: Recording and reporting details of silkworm and silkworm plant disease

2.2 Silkworm diseases

Disease is a condition in which a state of physiological equilibrium of the host with the environment. (Health) becomes unbalanced

Diseases usually has primary cause but there may be complex web of secondary causes contribute to disease incidence (pre-disposing factor) including environmental conditions. The major constraint of cocoon production are the occurrence of disease in silkworm.

Since mulberry silkworms are domesticated, they are susceptible to disease and pest attack

Major silkworm diseases

Common silkworm diseases are

1. Grasserie
2. Flacherie
3. Muscardine
4. Pebrin,

1. Grasserie

Figure 103: When stretched when contracted Larvae starts to turn dark

Symptoms

- The larvae will be sluggish with swollen inter-segmental region
- The larvae will be fragile

- On piercing, milky fluid containing many polyhedral inclusion bodies oozes out from the larval body
- The diseased larvae do not settle for moult
- The larvae appear to be restless
- The dead larvae hang by hind legs head downward
- Young age larvae may get infected with grasserie if the silkworm egg surface is not disinfected

Causes

- The Pathogen comes from infected eggs laid by infected mother moths
- May exist in rearing facilites or Mulberry gardens as spores
- Comes from wild insects naturally infected with *Nosema bombsycis*

Control

- Disinfect silkworm rearing house, its surrounding and appliances before brushing
- Conduct additional disinfection with 0.3% lime solution. Rear young silkworms as well as late age silkworms under strict hygienic condition
- Avoid high temperatures (28-35degC), low rearing temperatures (10-20degC) and rearing humidity (less than 70%)
- Dust lime uniformly when larvae settle for moult
- Dust every time the larvae come out of moult
- Feed quality Mulberry leaf

2. Flacherie

Figure 104: Stunted silkworms Larvae upon dying

Symptoms

The diseased larvae will be:

- Stunted in growth
- Dull and lethargic
- Soft and appear flaccid
- The thoracic region may be translucent
- The larvae vomit gut juice
- The larvae on dying rot and emit a bad smell

Control

- Clean and disinfect rearing trays once again. The pathogens contaminate the rearing tray, bed and Mulberry leaf in the bed. They survive in teh rearing tray/bed for a long time and cause the disease if they are not disinfected effectively.
- Control humidity as per guidelines above. If the temperature and humidty is too high in the tray/bed, the accumulation of faeces, wasted leaves and poor air circulation are suitable for the bacteria to multiply in the larvae and rearing bed.

3. Muscardine

Figure 105: Flaccid dead larvae

Symptoms

- The diseased larvae prior to death will be lethargic and on death are flaccid

- Oil specks may be seen on the surface of the larvae
- They gradually become hard, dry and mummify into white or green
- The diseased pupae will be hard, lighter and mummified

Control

- Disinfect rearing house and appliances
- Reduce silkworm bed humidity by dusting lime powder after bed cleaning
- Collect the entire diseased larva and burn them
- Practice rearing and personal hygiene during rearing
- Practice control measure against mulberry pests

4. Pebrine

Protozoan (Nocema bombycis) produce pepper like spot on body and larvae became wrinkle skinned and sluggish

Symptoms

- Diseases larvae show slow growth, undersized body and poor appetite.
- Diseases larvae reveal pale and fluecid bady. Tiny black spots appear on larvae integument.
- Dead larvea remain rubber and do not under go petrification shortly after death

Figure 106: Pebrine

Self-Check-2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Fill the blank space

1. Write the major silkworm disease (4%)

_____,_____

_____,_____

_____,_____

Answer the following question!

Note: **Satisfactory rating 5 and 9 points Unsatisfactory 5 below and 9 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = _____

Information Sheet 3: Recognizing egg, larvae, pupae and moth pests and diseases

3.1 Pests of silkworm

The following parasites and predators cause destruction of silkworm

A. Uzi flies: Tricholyga bombycid (dipteral), young maggots bore into the body **of** silkworms live in and eat fat body for about a week. Causing death.

Occurrence and Symptom:

The uzi fly, Exorista bombycis is a serious endo-larval parasitoid of the silkworm, Bombyx mori, inflicting 10-15% damage to the silkworm cocoon crop in the premier silk producing states of Karnataka, Andhra Pradesh and Tamil Nadu.

Uzi fly occurs throughout the year, but severe during rainy season. Presences of eggs or black scar on the silkworm body and maggot emergence hole at the tip of the cocoon are the typical symptoms of uzi fly attack.

As soon as the uzi fly enters into rearing house, it lays one or two eggs on each silkworm larva. After 2-3 days, egg hatches, enters inside the larva and feed on internal contents for 5-7 days, after which it comes out by rupturing the larva.

The maggot pupates in a dark corner or cracks & crevices in about 18-24 hours. The pupal stage lasts for 10-12 days. If the uzi fly infests at last instar, the uzi maggots come out after cocoon formation by making a circular hole.

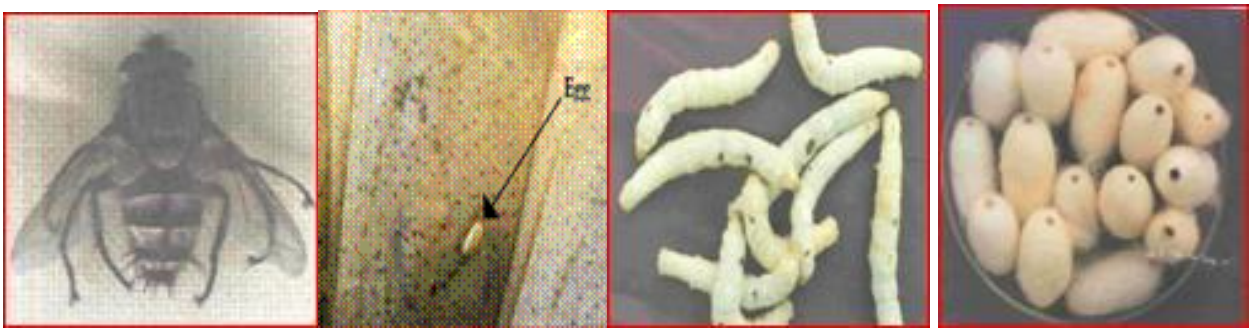


Figure 107: Uzi flies Egg of fly Black scar Dameded cocoon

B. Dermestid beetles: Dermestes cadeverinus larvae and adults feed on cocoons

Occurrence and Symptom:

Dermestid beetles, Dermestis

- Known to attack pierced cocoons in cocoon storage rooms
- The female beetles lay about 150-250 eggs in the floss of cocoons'
- The beetles migrate from cocoon storage room to grain age and attack green cocoons as well as moths.
- Generally, they attack the abdominal region of the moth.
- The damage estimated to be 16.62% on cocoons and 3.57% on moths.

Figure 108: Dermestid beetles Larvea and Adult feed coocans

C. Predators includes:

- Rats
- Birds
- Safari and Black ants
- Snakes
- Lizards
- Squirrels

Self-Check-3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Fill the blank space

1. Write the silkworm predators (5%)

_____,_____

_____,_____

_____,_____

Information Sheet 4: Selecting treatment methods for silkworm and silkworm plant disease

4.1 Treatment method of silkworm

Proper disinfection and strict hygiene will prevent diseases and ensure successful harvest.

4.2 Pest Control

- Put coffee tray wire mesh on all the windows, crevices and any other openings in the rearing house
- Maintain cleanliness both within and outside the house
- Sprinkle one layer of bleaching powder (calcium chloride) around the rearing house

4.3 General Controlling methods of silkworm disease

- Practice disinfection of rearing appliances before **use**. During rearing, test the fecal matters, unequal/ lethargic/ unsettled/ irregular moulters periodically. If pebrine spores detected, reject the entire infected crop. Ensure the measures for destruction of diseased **silkworm** larvae/cocoons/moths/eggs.

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Answer Key

Module Title: Assisting and Performing Seri-culture Activities
LO, #1 Participate in silkworm feed plant production

Self-check1

1_____is the practice of rearing silk worms for the production of raw silk=

Sericulture: (2%0

2. _____the removal of silk yarn from the cocoons= **Reeling (2%)**

3_____is silky envelope spun by larvae of silkworm protect pupas **=Cocoon (2%)**

4. List down the uses of sericulture contribution (3%)

- Gainful employment
- Economic development
- Improvement in the quality of life to the people in rural area
- Plays an important role in anti-poverty programmer
- Prevents migration of rural people to urban area in search of employment

5. Write the variate of mulberry plant (3%)

- Black mulberry
- White mulberry
- Red mulberry

6. Write the method of mulberry plant cultivation (3%)

Use cuttings and seeds

7. Write the parts of mulberry plant (3%0

Stem, Bud and Leaf.

8. Write the mulberry plant preferences (2%)

Loamy soil, Alluvial, Volcanic and black soil with pH 6.8-8.5

Self-check2

1. List down at least ten material used for sericulture (5%)

White bird's father, Local montages, Karaka (egg cards and egg case), Disaffecting material, Nylon string, Plastic tube watering, Chopstick, Pegs, Empty sack, Cleaning supplies (detergent), Long sheet (record book), Lumber and plywood, Hard cardboard, Bamboo basket, Cheesecloth, and Marker

2. List down at least ten tools and equipment used for sericulture (5%)

Refrigerator, Balance, Rule, Stiner, Beaker, Petri dish, Dropper, Graduating cylinder, Test tube, Buckets, Wheel barrow, Shovel, spades, forks and hoes, Try (rearing/feeding and seed), Rearing and feeding stands, Cleaning net

3. List down personal protective equipment used for sericulture (5%)

Overalls**,** Gloves**,** Safety goggles**,** plastic boots/shoes**,** Sunhats**,** Respiratory musk **,** Helmet and Aprons,

Self-check3

1. Mulberry (Morus) believed to have originated in the (2%) _____= northern hemisphere

2. Write the historical order of mulberry plant distribution (5%)

China, Korea, Japan, India, Persia, Italy, Belgium, France England, America, Germany, Russia, Denmark and Sweden

3. ___ the first county to develop sericulture development (2%) **China.**

Self-check4

1. Write the leaf morphology of white mulberry plant (6%)

- Simple
- Alternate
- Stipulate
- Petiolate
- Entire, or lobed
- The number of lobes varies from one to five

2. Write the factor contribute for leaf sheep variation of mulberry plant (4%)

- Age of the plant
- Growth
- positions in the branches
- Period of growth, etc.

3. Write factor contribute for mulberry plant to changes its' sex (3%)

- Physical injury
- Pruning
- Environmental conditions

4. Write the two layer of mulberry seed coat (2%)

- The outer hard and brittle layer called the teste
- The inner thin papery and slightly brownish layer called the **segment**.

Self-check5

1. Write the soil types required for mulberry plantation and range of PH.(5%)

- Flat
- deep fertile
- well drained
- loamy to clayey
- porous with a good moisture holding capacity
- The ideal range of soil pH is 6.2 to 6.8
- Mulberry grown in soil like:
  - ✓ Saline
  - ✓ alkaline and acidic soils after suitably amending the soils
- Preparation of land.

2. Write the mulberry discretion habit (3%)

- A fast-growing
- small to medium-sized tree growing to 10 –20 m tall
- generally a short-lived tree although there are some specimens known to be over 250 years old
- Most leaves are not lobed
- The juvenile growth is often lobed.

3. Write the small mammals that feed on mulberry plants. (3%)

- Birds
- Foxes
- squirrels and rodents
- Deer browse on the

4. Write the types mulberry reproduction type (2%)

- Sexual Reproduction
- Propagation

5. Write the Potential Problems mulberry plant (3%)

- Invasive
- Pest and Disease
- Allergies

Self-chek6

1. ____ is an agro-industry which means, combining both agriculture and industry final product is silk =**Sericulture**

2. Write the criteria for select variety of mulberry for production:

- Fertility of the land
- Water avialability
- Region specificity
- Tthe extent of the garden and problematic soilss

4. Write the factor infulence space required for mulberry caltivation

- The soil condtions
- Slope
- Variety and convenience for inter-cultural operation
- The yield potential of high yielding varieties can be best realized in high fertility soils
- Respond to intensive irrigation Wherever the size of the operation is bigger.

Self-check7

1. Write the corrective method used acidic soil below five PH for mulberry plantation (2%)

- application of **Dolomite** or **Lime**

2. Write the corrective method used alkaline soils for mulberry plantation (2%)

- **application of Gypsum**

3. Write the the ideal annual rain fall requirment and tempareture of mulberrty plant (2%)

- Annual rain fall 600 to 2 500 mm
- Temprature 24 to 28°C.

4. Write the mulberry plantation managements factors (4%)

- Weeding and Inter-cultivation in mulberry farming
- arining and Pruining of mulberry plants
- Manuring and fertilizer of mulberry plants
- Managing Irrigation requirment for mulberry plantation

Self-check8

1. Write the nine types of castor bean (9%)

- Carmencita Bright Red
- Carmencita Pink
- Carmencita Rose
- Gibsonii
- Impala
- New Zealand Purple
- Red Spire
- Sanguineus
- Zanzibarensis

Self-check9

1. Write the cultivated varieties castor plant with strikingly different foliage colorations (5%)

- Black-purplish
- Dark red-metallic
- Bronze-green
- maroon
- Bright green with white veins
- Just plain green

2. write the leaf color of castor bean species(5%)

- Glossy green
- Blackish purple
- Deep red metallic
- Maroon
- Bronzish green leaves with white veins

3. Write the types of soil castor plant perfer to growth.(3%)

- Red,
- Sandy loam
- Light alluvial soils

Sel-check10

1. Write the Castor plantation procedure (6%)

- Seedbed Preparation
- Seeding Date
- Method and Rate of Seeding
- Fertility and Lime Requirements
- Variety Selection
- Growth Habit

2 List down the use of castore bean product (5%)

- Used as lubricant in high speeds engines
- aero planes
- In the manufacture of soaps
- Transparent paper
- printing inks
- Varnishes
- Linoleum and plasticizers
- Used for medical and lighting purposes
- Castor leaves fed to silkworms

Self-check11

1. Write the procedure of castor plantation activities

- Preparation of the field
- Application of organic manures
- Identify Seed rate
- Identify Spacing
- Application of fertilizers
- Pretreatment of seeds

- Sowing

2. Write the castor bean sowing procedures (4%)
   - Sow the seeds adopting the recommended spacing.
   - Place the seeds at depth 4 - 6 cm.
   - Put one seed in each hole.
   - Gap filling
   - Gap fill on the 15th day of sowing and simultaneously thinning done leaving one healthy plant.

Self-check12

1. Write the procedure of castor plant disease problems methods (4%)
   - Rotation planting program
   - Treatment of seed with a fungicide prior to planting recommended
   - Thrum is the only registered seed treatment fungicide.
2. Write the castor plant weeds management methods (3%)
   - Weed Control
   - Intercropping

LO #2 Monitor silkworm seed techniques, morphology and physiology of silkworm

Self-check1

1. _____very important basic material for the production of silk (2%) =Silkworm eggs
2. Write the definition of quality of silkworm seed (4%)
   - Free from diseases
   - Has more number of good egg
   - Gives uniform hatching
   - Assures a stable cocoon crop.
3. Mention the consist drainage operations of silkworm seed (3%)
   - Selection
   - Storage
   - Preservation of seed cocoons.

4. Write the of Steps silkworm seed production (5%)

- Procurement of seed cocoons in the seed market
- Preliminary examination/ selection and sorting of seed cocoons
- Preservation of seed cocoons
- Sex Separation at pupal and moth stage
- Identification of male and female moths
- Synchronization
- Coupling and decoupling
- Ovipositional

5. Write the methods silkworm eggs preservation (3%)

- Short-term refrigeration for 3 months
- Refrigeration for 4 and 6 months
- Long term refrigeration (10 months):

Self-check2

1. Write the two method artificial hatching (3%)

- Cold Treatment/ Physical methods
- Chemical Method / Acid Treatment

2. Write the hot acid treatment purposes (3%).

- This treatment practiced just between 15-20 hrs of ovipositional
- The egg diapason characteristics treated.
- When the treatment postponed the eggs preserved at 5ºC 20th hour

3. Write the uses of bivoltines, eggs to terminate the diapause (5%)

- Treated with HCl to get hatching in about 10 days
- In case of sheet eggs, the egg sheets should dipped in 2% Formalin for 10 minutes for surface sterilization
- Increase adherence of eggs to sheets
- Commercial grade of HCl available is of 1.15-1.18 specific gravity
- Prepare the required specific gravity acid by adding water
- Correct age of acid treatment is 20-24 hours after ovipositional

Self-check3

1. Write the two fibers (3%)
    - Natural fiber
    - Natural fiber
2. Write the life cycle of stages of silkworm (5%)
    - Egg
    - Silkworm
    - Cocoon
    - Pupa
    - Moth

Self-check4

1. Write the types of silk that dominance the world. (#%)
    - Mulberry silks Mulberry silk
2. Write the three types of non-mulberry silk (3%)
    - Eri silk
    - Tasar silk
    - Muga silk.
3. Write the types of Silk weaves (6%)
    - Chiffon
    - Organza,
    - Doupioni
    - Pongee
    - Faille

Self-check5

1. Mention the main organs of the larval body (5%)
    - Digestive organ
    - Dorsal vessel
    - Circulatory organ
    - Malpighian tubules
    - Respiratory organ
    - Nervous system

- Sensory organs
- Reproductive organs
- Fat tissues
- Muscles.

2. Write the digestive system of silkworm larvae (3%)
   - The fore-gut or stomodeum
   - Mid-gut or mesenteric
   - Hindgut or proctodeal.
3. Write the three pairs of Malpighian tubes (3%)
   - One tube in one-group runs along the dorsal wall of the midget towards the anterior side and turns backwards at the 4th abdominal segment
   - Second tube runs along midget to laterally and turns backwards at the point of center of 4th and 3rd abdominal segment
   - The remaining one tube also passes along ventral wall of the midget and turns backwards at the 3rd abdominal segment

LO #3 Silkworm rearing techniques

Self-check1

1. Write the special requirement of silkworm built (3%)
   - Adequate ventilation
   - Light
   - Rodent proof
2. Write the site selection criterial of silkworm rearing house (3%)
   - **Built away from farm animals**
   - Near the mulberry field
   - Doors and windows should be North-South direction
3. Write the locally available materials used to build silkworm house (5%)
   - Bamboo
   - Off cuts
   - Timber
   - Stones

- Mud
- Bricks etc. to build the walls.

Self-check2

1. Write the three primary steps of mulberry silk production process (3%)

- **Mori-culture**
- **Silkworm rearing**
- **Silk reeling**

2. Mention the silkworm molting sign (3%)

- woolen heads
- Raised heads
- Worms are immobile

Self-check3

1. Write the room or house of silkworm disinfection procedures (4%)

- Kept airtight during disinfection and should remain closed for 15 - 20 hours after disinfection
- Opened 24 hours prior to introduction of silkworms
- Disinfection is done using 2% formalin solution
- To achieve this, add 1lt of formalin concentrate into 19 lt of water
- Require 40 of formalin solution to cover a room of 5m x 7m x 3m
- Before Disinfection all rearing equipment cleaned and returned into the rearing

2. Write the temperature and humidity range requirement based on the silkworm age (3%)

- Silkworms do well in a temperature range of 23-28^{0}C
  - ✓ High temperatures for the younger worms
  - ✓ Lower temperatures for the older worms.
- Humidity range from 70-85 %
  - ✓ High for the younger worms
  - ✓ Low for the older worms

3. Write the optimum temperature and humidity range required for silkworm incubation (2%).

- Optimum temperature 25^{0}C

- Humidity range 80% - 85%

4. Write the length of silkworm hatching (2%)
    - Hatching length 10-12 days
5. Write the two methods of brushing newly hatched Silkworms (2%)
    - Brushed with a feather
    - Chop tender

6_____ transferring mature silkworms from rearing beds to montages to start spinning (2%). = **Mounting**

L**O #5 Report silkworm feeds plant and treat silkworm disease, pests and predators**

Self-check 1

1. Write the fungus disease of mulberry plant (2%)
    - Powdery mildew
    - Leaf spots
2. List down mulberry plant insect pest. (4%)
    - Leaf eating caterpillar (Dircrisia oblique)
    - Jassid (Empoasca flavescens)
    - Mealy bug (maconellicoccus hirsutus),
    - Scale insects
    - Thrips
    - Stemgirdler beetle (sthenia grisator)
    - Powder pestbeetle (sinaxylon pubens)
3. Write the castor plant disease (4%)
    - Seedling blight
    - Alternaria blight
    - Cercospora leaf spot
    - Powdery mildew Powdery mildew
    - Wilt
4. Write the pest of castor (4%)
    - Red hairy caterpillar Amsactaalbistriga, A. mooreii
    - Tobacco caterpillar Spodoptera litura

- ihar Hairy Caterpillar Spilosom aobliqua
- Capsule Borer: Conogethes (=Dichocrosis) punctiferalis
- Jassids: Empoasca flavescens
- White flies Trialeurodes ricini
- Thrips Retithrips siriacus: Scirtothrips dorsalis

Self-check3

1. Write the silkworm predators (5%)

- Rats
- Birds
- Safari and Black ants
- Snakes
- Lizards
- Squirrels

2. Write the major silkworm disease (4%)

- Grasserie
- Flacherie
- Muscardine
- Pebrin,