SEMESTER 3 AND SEMESTER 5 (SEC)
UNIT 3

Mulberry is a fast growing deciduous woody perennial plant. It has a deep root system. The leaves are simple, alternate, stipulate, petiolate, entire or lobed. The number of lobes varies from one to five. Lobes are more common on juvenile shoots than on mature trees. Inflorescence is catkin with pendent or drooping peduncle bearing unisexual flowers. Inflorescence is always auxiliary. Male catkins are usually longer than the female catkins. Male flowers are loosely arranged and after shedding the pollen, the inflorescence dries and falls off. Female inflorescence is usually short and the flowers are very compactly arranged. Number of parianth lobes are 4 and persistent. Ovary is one-celled and stigma is bifid. The chief pollinating agent in mulberry is wind. Fruit is a sorosis and the colour of the fruit is mainly violet black. The mulberry fruit is a multiple, about 2–3 cm long. Immature fruits are white, green, or pale yellow. The fruit turns from pink to red while ripening, then dark purple or black, and has a sweet flavor when fully ripe.

There are about 68 species of the genus *Morus*, the majority of them occur in Asia, especially in China (24 species) and Japan (19). Continental America is also rich in its *Morus* species. The genus is poorly represented in Africa, Europe and Middle East, and it is not present in Australia. In India, there are many species of *Morus*, of which *Morus alba*, *M. indica*. M. *serrata* and *M. laevigata* grow wild in the Himalayas. Several varieties have been introduced belonging to *M. multicaulis*, *M. nigra*, *M. sinensis* and M. *phillippinensis*. Most of the Indian varieties of mulberry belong to *M. indica*.

Selection of Mulberry varieties under cultivation in different states

Variety	Region	Developed at	Origin
Kanva-2	South India Irrigated	CSRTI, Mysore	Selection from natural variability.
S-36	"	"	Developed through EMS treatment of Berhampore Local.
S-54	"	"	"
Victory-1	"	"	Hybrid from S30 x Ber C776.
DD	"	KSSRDI, Thalaghattapura	Clonal selection.
S-13	South India Rainfed	CSRTI, Mysore	Selection from polycross (mixed pollen) progeny.

S-34	"	"	"
MR-2	"	"	Selection from open pollinated Hybrids.
S-1	Eastern and N.E. India Irrigated	CSRTI, Berhampore	Introduction from (Mandalaya) Burma.
S799	"	"	Selection from open pollinated Hybrids.
S1635	"	"	Triploid selection.
S146	N.India and Hills of J & K Irrigated	"	Selection from open pollinated hybrids.
Tr-10	Hills of Eastern India	"	Triploid of Ber.S1.
BC 259	"	"	Back crossing of hybrid of Matigare local x Kosen with Kosen twice.
Goshoerami	Temperate	CSRTI, Pampore	Introduction from Japan.
Chak Majra	Sub-temperate	RSRS, Jammu	Selection from natural variability.
China White	Temperate	CSRTI, Pampore	Clonal selection.

Establishment of mulberry garden (Irrigated condition)

i) Selection of site: Mulberry flourishes well in soils which are flat, deep, fertile, well drained, loamy to clayey, porous with good moisture holding capacity. The ideal range of soil pH is 6.2 to 6.8. Mulberry can be grown in saline, alkaline and acidic soils after suitably amending the soils.

ii) Preparation of land: The land meant for mulberry cultivation is ploughed deep with heavy mould board plough up to a depth of 30 – 35 cm. Thereafter the land is repeatedly ploughed 2-3 times with a country plough to bring the soil to a fine tilth. The land should be properly leveled if it is sloppy. A basal dose of well decomposed farm yard manure or compost is applied at the rate of 20 MT/ha and thoroughly incorporated into the soil.

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

iv) Spacing: Plant spacing of 90 x 90 cm. is ideal for mulberry. While taking Plantation directly, two cuttings/pit required to be used. In case of using saplings, only one sapling/pit is sufficient. Presently a paired row plantation with the spacing of (90+150)cm x 60cm, is recommended.

v) Inter-cultivation: Two months after planting, weeding is done. A second weeding is done after another 2-3 months. Thereafter, inter-cultivation should be done after every shoot or leaf harvest.

vi) Irrigation: The plantation should be taken up during the onset of monsoon to take advantage of the rains. If the rain is not sufficient, the land should be irrigated at regular intervals of 8-14 days depending on type of soil. About one and a half to two acre inches of water is required/irrigation.

vii) Application of fertilizer: The total dose of fertilizer to be applied in first year is 100 N: 50 P: 50 K/kg/ha/yr. This is applied in two doses. The first dose is applied when the plantation is about 2 months old at the rate of 50 N: 50 P: 50 K/kg/ha. The second dose is applied after taking the leaf harvest at the rate of 50 kg N alone/ha.

viii) Pruning: After 6 months of plantation, mulberry attains a height of about 1.50 to 1.75 m. and is ready for harvest. The first harvest is taken by bottom pruning. The second leaf harvest is taken after 12 weeks of first leaf harvest and the third harvest is taken 12 weeks after the second harvest by shoot harvest. From second year onwards, harvest is made at an interval of 70 days by shoot harvest method.

ix) Leaf harvest: Leaf harvesting is done either through individual leaf harvest or shoot harvesting. Later one is more economical and useful for shoot method of silkworm rearing.

Maintenance of Mulberry under Irrigated Conditions (Second year onwards)

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

Recommended inputs: i) FYM/compost	20 MT	In two equal split doses (10 MT FYM+ MT vermi compost)
ii) Azotobacter	20 kg	In five equal split doses

iii) N-triacontanol***	250 ml	In two equal split doses/crop
iv) VAM inoculum** (for existing garden)	1000 kg	One dose in the life span of mulberry (inoculation through maize as host plant)
v) Ammonium* sulphate or Urea or CAN	750 kg 325 kg 600 kg	In five equal split doses
vi) Single super Phosphate	375 kg	In two equal split doses(I and III crop)
vii) Muriate of potash	200 kg	In two equal split doses. (I and III crop)

* 50% of chemical fertilizer can be cut down due to application of azotobacter and VAM.
** VAM inoculation is not required for the garden, planted with Mycorrhiza inoculated saplings.
*** 1st spray: In between 10-15 days after pruning/leaf plucking 2nd spray: 10 days after Ist spray.

Establishment of Mulberry (Rainfed Condition)

i) Preparation of land: The land meant for mulberry cultivation is ploughed deep with heavy mould board plough up to a depth of 30-35 cm. Thereafter the land is repeatedly ploughed 2-3 times with a country plough to bring the soil to a fine tilth. The land should be properly levelled if it is sloppy. A basal dose of well decomposed Farm Yard Manure or compost is applied at the rate of 10 MT/ha and thoroughly incorporated into the soil.

ii) Spacing: The spacing commonly followed for a rainfed garden is 90 x 90cm Pits of 35 x 35cm. are prepared. About 1 kg farm yard manure/pit should be added.

iii) Preparation of cutting and planting: Branches of 8-10 months old and about 50 mm. in diameter should be used for preparation of cuttings of 22-25 cm. length with 5-6 healthy buds. Three cuttings are planted/pit in a triangular form with a spacing of 15 cm. leaving only one bud exposed above soil surface. If planting is done with saplings, then one sapling is sufficient/pit. Planting should be done during June /July after onset of monsoon.

iv) Inter cultivation: During first year of plantation, inter-cultivation should be done manually. Once the mulberry plants are established, bullock ploughing is carried out.

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

First dose

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

Second dose

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

v) Pruning and leaf harvest: First crop should be taken 6 months after plantation when mulberry gets well established. Then onwards, two more crops are taken during first year by leaf picking method. Mulberry should be pruned after the completion of one year at the onset of next monsoon. The pruning is carried out with a sharp sickle or a pruning saw at the height of 25-30 cm. from the ground.

vi) Green manuring and cover mulching: Green manure crops can be grown as inter-crop with mulberry. It should be done during monsoon only. The green manure crops (cow pea, horse gram, dhaincha) should be incorporated into soil by ploughing before the flowering starts and well before rains cease. After that the plots may be given cover mulching with any dry material or weeds in which seed is not a source of multiplication.

Maintenance of Mulberry Under Rainfed Condition (Second year onwards)

Inputs required for rainfed garden (per ha. per year)
Recommended inputs for gardens maintained under rainfed condition.
Spacing : 90 cm. x 90 cm.

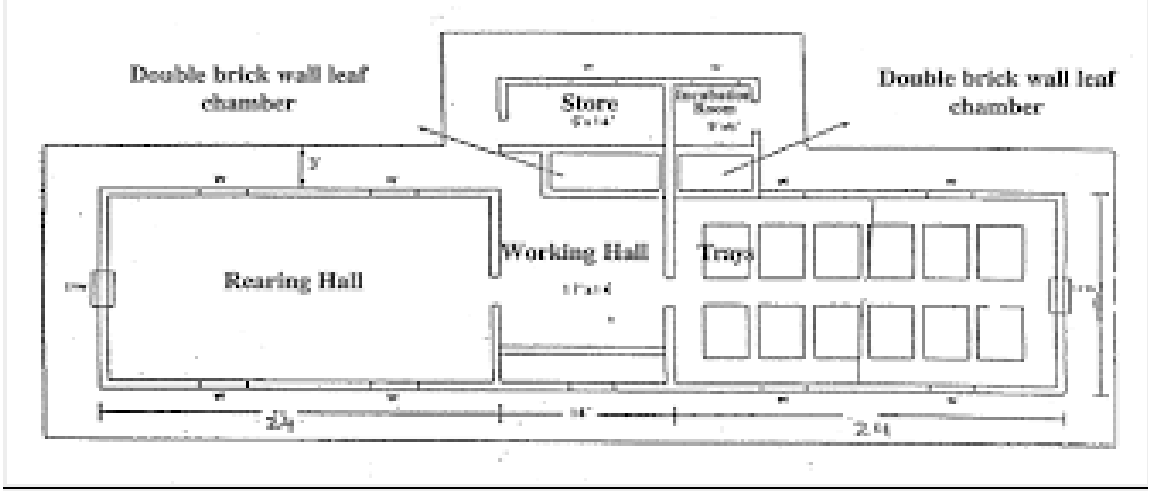
1. FYM/compost, 10 MT, single dose at the onset of monsoon
2. Azotobacter biofertilizer, 4 kg/crop, two times/yr (during rainy season)
3. VAM inoculum, 1000 kg, once in life span of mulberry (inoculation through maize rootlets)
4. Suphala, 167 kg, I crop
5. Single Super Phosphate, 156 kg, I crop
6. Muriate of potash, 42 kg, I crop
7. Urea (55 kg) or Cam (100kg), III crop
8. Green manuring, 15 kg

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

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

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

Rearing House



- The roof of the house should be of either Asbestos sheets or RCC to avoid entry of the Uzi-fly. In hot regions, coconut fronds or straw should be placed over the roof to avoid heat radiations during day time. A false ceiling of plywood or thermocol sheet is also effective in reducing the solar radiation from roof. The minimum width of a rearing house for late age rearing should be 5.5 m (18').
- The wall height in a rearing house should be minimum 10' on the sides and 14' at the center.
- An ante-room should be provided for washing hands and disinfecting legs before entering into the rearing area.
- Doors and windows should be fitted with wire mesh to avoid entry of uzi-fly into the rearing house.
- Water facility should be provided in a rearing house for cleaning/washing and disinfection and also for humidification purpose.
- The rearing house should have adequate lighting arrangements for working during night.

- Electrical points in the rearing house should be provided for using heaters, humidifiers, coolers and lighting the building for workers during night hours.
- Provisions must be made for exhaust fans for evacuating humidity from rearing house during rainy days.
- Arrangements should be made to ward off rats, lizards, etc. and avoid entry into the rearing house.
- Shade trees around the rearing house should be planted to protect the walls and the roof from afternoon sun.
- A silkworm rearing house should be well ventilated. Poor ventilation leads to humidity built up and accumulation of gases like carbon monoxide, carbon dioxide, ammonia, etc., which adversely affect the growth of silkworms and make them susceptible to diseases.

Rearing Appliances

- Power sprayer
- Rearing stands and Rearing trays
- Foam pads
- Ant well
- Wax coated paraffin papers
- Nylon nets
- Basket for keeping leaves
- Gunny bags
- Chop stick
- Feather
- Chopping board and knife
- Rotary or Bamboo Mountages.

Disinfectants and Disinfection Methods

Disinfection is an integral part of healthy and successful silkworm rearing. It aims at the total destruction of disease causing pathogens. Several diseases caused by bacteria, viruses, fungi and protozoa affect the silkworms. These pathogens released by diseased silkworms easily accumulate and spread in the rearing environment through different routes. They are not easily destroyed and can persist / survive for long periods under congenial conditions. The spores of the pathogens, especially those of fungi are light and can easily be drifted by air current resulting in easy spread of diseases. There are no curative methods for any of the silkworm diseases and they are best prevented than cured. This is achieved by adoption of proper and effective methods of

disinfection and stepwise maintenance of hygiene during rearing. To realize the benefit of disinfection (mass) and rearing at village or block level considering them as one unit.

Chemical Disinfectants available for use in Sericulture

Formalin- It is commercially available as 36% formaldehyde in solution form. A mixture of 2 % formalin + 0.05 % detergent is an effective solution that can be used for disinfection purpose as spray. Formalin is effective only in rearing houses, which can be made airtight and it is faster and more pronounced at temperature above 25 ^{0} C and humidity more than 70 %.

Bleaching powder- It is white amorphous powder, with a pungent smell of chlorine. For effective disinfection, a high-grade bleaching powder with an active chlorine content of 30 % must be used. It should be stored in sealed bags, away from moisture, failing which it will be rendered ineffective. The action of bleaching powder is optimal under wet and contact conditions and therefore the surfaces of equipment and walls should be drenched with this solution. A 2% bleaching powder in 0.3 % slaked lime solution is used for disinfection as spray.

Slaked lime- A very useful bed disinfectant in sericulture. especially against viruses. It absorbs moisture and can be used to regulate bed humidity and maintain hygiene. Application of lime dust in combination with bleaching powder in and around rearing houses and premises improves hygiene in the environment.

Resham Keet Oushadh (RKO) is a bed disinfectant which can be applied on the silkworm rearing bed to inactivate pathogenic microbes responsible for muscardine, Grasserie and nuclear polyhedrosis diseases in silkworm. RKO is economical and its usage increases the cocoon yield on an average of 7.00 kg per 100 diseases free layings (dfls). It is easy to use and has no adverse effect on silkworm health, human beings and domestic animals. The quantity of RKO required for treating 100 dfl's is 3.25 kg. RKO is produced from locally available chemicals and the shelf life of RKO is six months from the date of manufacture.

Silkworm Rearing

The rearing of the mulberry silkworms is fully domesticated. A silkworm-rearing house is the place where the silkworms are reared to produce cocoons. The cocoon quality and yield are adversely affected if the optimal environmental conditions i.e. temperature, relative humidity, ventilation, illumination; hygiene, etc. are not provided to the silkworms. The rearing house should be rationally designed in order to keep the micro-climatic and environmental conditions

for rapid and healthy growth of the silkworms. It should, therefore, have facilities for creation and maintenance of the optimal environmental conditions inside the silkworm-rearing house. The rearing house should also provide sufficient space and healthy environment for the workers attending the silkworm rearing.

Optimal Environmental Conditions for Silkworm-

The optimum rearing temperature and relative humidity for different stages of the silkworms are as follows:

Instar	Temperature°C	RH %
I	27-28	85-90
II	27-28	85-90
III	26-27	75-80
IV	25-26	70-75
V	25-26	70-75

When the temperature and relative humidity inside the rearing house are below optimum conditions, they are artificially raised through charcoal or electric heaters and running humidifiers. When the rearing room temperature and relative humidity are above the optimum conditions, arrangements for natural cooling through good ventilation or forced cooling through wet curtains on windows, air coolers or air conditioners should be made besides covering the roof with mats made up of coconut fronds, grass etc.

Light -Young Silkworms prefer dark or dim light [15-30 lux]. Light intensity influences the even distribution of the larvae in the rearing bed.

Ventilation - A silkworm rearing house should be well ventilated. Poor ventilation leads to humidity built up and accumulation of gases like carbon monoxide, carbon dioxide, ammonia, etc., which adversely affect the growth of silkworms and make them susceptible to diseases.

Rearing Bed Area Requirement for Silkworms-

Rearing bed area required for silkworms during different stages for 40000 larvae.

(1 sqm=10 sq.ft.)

Instar	Bed area for Multivoltine (sqm/sqft.)	Bed area for Bivoltine (sqm/sqft.)
First	1.50/15	1.75/17.5
Second	4.50/45	5.25/52.5
Third	9.00/90	12.00/120
Fourth	24.00/240	133.00/330
Fifth	50.00/500	77.00/700

Silkworm rearing (Chawki rearing)

The young age silkworm rearing or Chawki rearing is a vital aspect of sericulture industry for the development of healthy larvae and harvesting of successful cocoon crop. Rearing of young age silkworms up to 2nd moult is called as chawki rearing. This stage of larvae requires ideal environmental conditions, tender mulberry leaves. Robust growth and development of chawki larvae make them resistant to diseases and more stress tolerant during later stages of development.

Characteristic of chawki worms

- Young age worms grow very fast.
- Show resistance to high temperature (27"C to 28'C) and humidity (80-90%).
- They are fond of dim light of 15-20lux and avoid strong light and darkness.
- They are rather strong to low air circulation of 0.3 m per sec.
- Have low ingestion and high digestibility.
- They are weak to carbonic gases.
- They are highly susceptible to the diseases.
- Newly hatched larvae have low water content, but once intake of mulberry leaf starts, water content rapidly increases to 76-79% during 1st instar and 83- 85% during 2nd instar.
- The optimum temperature for chawki rearing is 27-29˚C and humidity 85- 90 per cent, below that condition the physiology of silkworm is affected. The environmental factors like temperature, humidity, light and air have great influence on growth and development of silkworm.

Late age rearing

Rearing of fourth and fifth instar worms is called as late age worm rearing. These worms require less humidity and preferable low temperature. This stage is the real feeding stage. The worms consume about 90 to 95 percent of the total feed. When chawki worms are reared perfectly, late age rearing is comparatively easy. As this is the final stage of rearing, worms are fed proper with quality leaves to get good crops.

The fourth and fifth instars of silkworms are more delicate and require rigid conditions of temperature and humidity. During these stages the worms not only develop silk glands and secrete silk, but also store the food for coming series of metamorphosis. Therefore these worms are fed with quantity leaves. These worms eat mature leaves which contain less moisture. During this period silkworm body volume increases by 29 times, body weight by 25 times and silk gland weight by 200 times. Thus rearing at these stages influences quality and quantity of cocoon crop production.

Temperature-The adult silkworm is susceptible to high temperature. The larval mortality increases when young worms are reared in low temperature (24 °C) and late age rearing in high temperature (28 °C). Temperature influences to alter various physiological aspects which intern reflects on silk characters and production. Therefore wide fluctuations of temperature should be avoided. The optimum temperature required for late age worms are:

Stage of Worms Optimum Temperature

IV 24 °C – 25 °C

V 23 °C – 24 °C

Humidity -Late instar worms are sensitive to high humidity. The humidity requirements during feeding and moulting are quite different in silkworm. The optimum humidity required for IV and V instars is 75% and 70% respectively. During feeding high humidity is maintained which favours to keep the freshness of leaves fed to silkworms for sufficient consumption. During moulting process maintenance of low humidity is preferable.

Air-The air in the rearing room is polluted by carbon monoxide, CO2, NH4, SO2. These pollutants are produced by working men, silkworms, mulberry leaves, fermentation of leaves, burning of charcoal. After finishing the daily rearing activities such as feeding, cleaning, spacing generally the room is closed, or poorly ventilated without knowing its effects. Then the injurious gases increase to a significant level and affect the worms. Therefore windows should be wide open to improve the air current. The growth of the silkworms and air current are correlated, Carbon dioxide content exceeding one per cent in the rearing room is bad for silkworms. During high temperature, the CO2 released by silkworms increases in proportion to the humidity. Air current of 1.0 meter per second during V age rearing considerably reduces larval mortality. Further it improves ingestion, digestibility, larval weight, cocoon weight and pupation rate.

Light: Rearing of silkworms in continuous light delays growth. Further it causes pentamoulters and reduces both larval and cocoon weights. Silkworms are fond of dim light of 15 to 20 lux and avoid strong light and darkness. Late age worms thrive better in 16 hours light and 8 hours dark periods.

During late fifth instar, after completing the feeding silkworms reaches the ripened stage (ready –to-spin silk). Ripened silkworms are identified by their characteristics movement to the corners of the rearing treys, reduction in size by one-third and transparent yellow appearance. These ripened silkworms are transferred to the mountages (equipment to provide support for cocoon formation) for spinning cocoons.

Types of Montages

In India following types of mountages are used:

1) Traditional Bamboo Montage (Chandrika)

- Common in Southern part India.
- Standard Size 180x120 cm (6'x4')
- Can accommodate 900-1000 mature worms
- Easy availability
- Absorbs moisture easily
- Demerits: Falling of dead and diseased larvae on the floor leads to contamination.
- Separate space required for mounting and storage of mountages.
- Due to sagging of spirals - uneven space for cocoon construction.
- More space required for storage.
- Time and labour consuming for mounting.
- Difficulty in handling of mountages.
- Less life span (about 3 - 4 years)

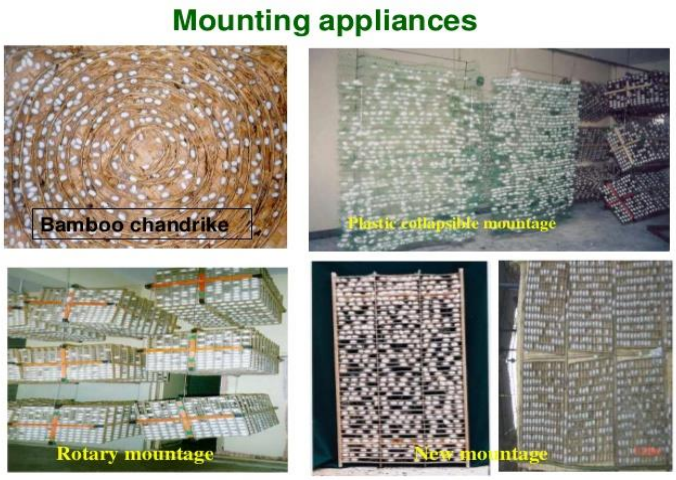
2) Plastic collapsible mountage

- Standard size 90x60 (3' x 2')
- Can accommodate 300 – 350 larvae
- Lighter in weight

- Less space for storage
- Easy to handle and disinfect
- Demerits: Easily damaged by rodents

3) Rotary mountage

- Size 55 cm x 40 cm
- Each set accommodate 1560 larvae
- Uniform size and shape
- Defective cocoons are less
- Easy - harvesting -Storage and disinfection
- Higher reelability and improved reeling parameters
- Disadvantages : High initial investment
- Separate space for mounting



Harvesting of cocoons

- Cocoons should be harvested after 5thday of mounting.
- Cocoon should be sorted separately as per their quality
- Cocoons should be carried in thin gunny bags / nylon nets to the nearest cocoon market.
- Cocoons should be transported to the cocoon market in the early hours of the day.