



## Udai Pratap (Autonomous) College, Varanasi

### E-learning Material

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## Sericulture :

**Sericulture** is mainly practised in five states namely, Karnataka, Andhra Pradesh, Assam and Bodoland, **West Bengal, Jharkhand and Tamil Nadu** are major silk producing states in the country. **India** is the second largest producer of silk in the world.

**Sericulture** is the process of cultivating silkworms and extracting silk from them. The caterpillars of the domestic silkworm (also called '*Bombyx mori*') are the most commonly used silkworm species in **sericulture**. Other types (4 types) of silkworms (such as Mulberry Silk, Eri Silk, Muga Silk, and Tasar Silk) are also cultivated

for the production of ‘wild silks’. Which are mention below and identified on the basis of colour, insects and Plant.

<b>Type of Silk</b>	<b>Colour</b>	<b>Types of Silk Insect</b>	<b>Food Plants</b>
<b>Mulberry Silk</b>	Yellow/Green	<i>Bombyx mori</i>	<i>Moras alba</i> <b>(Mulberry)</b>
<b>Eri Silk</b>	Creamy-White/Brick-Red	<i>Attacus ricini</i>	<i>Ricinus communis</i> <b>(Castor)</b>
<b>Tasar Silk</b>	<b>Copper-Brown</b>	<i>Antheraea mylitta</i> , <i>Antheraea paphia</i> , <i>Antheraea royeti</i> , <i>Antheraea proyeli</i>	<i>Terminalia arjuna</i> <b>(Arjun)</b> <i>Terminalia tomentosa</i> <b>(Asan)</b> <i>Sorea robusta</i> <b>(Sal)</b> , <i>Zozyphus jujube</i> <b>(Plum) etc</b>
<b>Muga Silk</b>	<b>Golden</b>	<i>Antheraea assama</i>	<i>Tetraanthera monopetala</i> <b>(Som)</b> , <i>Michalia oblonga</i> <b>(Champa)</b> , <i>Listea citrate</i> <b>(Moyankuri)</b>

Sericulture is a very important domestic industry in many countries. **India and China are the world’s leading producers of silk.** The silk output of these two countries combined accounts for over 60% of the global production.

Silk is the most elegant textile in the world with unparalleled

grandeur, natural sheen, and inherent affinity for dyes, high absorbance, light weight, soft touch and high durability and known as the “**Queen of Textiles**” the world over.

On the other hand, it stands for livelihood opportunity for millions owing to high employment oriented, low capital intensive and remunerative nature of its production. The vary nature of this industry with its rural based on-farm and off-farm activities and enormous employment generation potential has attracted the attention of the planners and policy makers to recognize the industry among one of the most appropriate avenues for socio-economic development of a largely agrarian economy like India.

Silk has been intermingled with the life and culture of the Indians. India has a rich and complex history in silk production and its silk trade dates back to 15th century. Sericulture industry provides employment to approximately 8.25 million persons in rural and semi-urban areas in India during 2015-16.

Of these, a sizeable number of workers belongs to the economically weaker sections of society, including women. India’s traditional and culture bound domestic market and an amazing diversity of silk garments that reflect geographic specificity have helped the country to achieve a leading position in silk industry.

## **Habit and Habitat :**

Out of four different kinds of silk types the two Mulberry and Eri silk are manufactured from domesticated silkworm. Where as

Tasar and Munga silk worms are wild type in nature. All the silk worms are found on leaves of plants according to their types. Mulberry Silk worm found on Leaves of *Moras alba* (Mulberry) and Eri Silk worm on *Ricinus comunis* (Castor) plants and Tasar Silk worm on *Terminalia arjuna* (Arjun) plant and Munga Silk worm on leaves of *Tetraanthera monopetala* (Som) and *Michalia oblonga* (Champa) plants.

## Life Cycle of Silk Worm :

The life cycle of these four types of Silk moths are much in common, as they lay eggs, from which caterpillar hatches. They eat, grow and produces cocoon for their protection, then pupae inside cocoon. After some times moths emerges from the cocoon, male and female mate, lay eggs and repeat their life cycle.

The adult of *Bombyx mori* is about 2.5 cm in length and pale creamy white in colour. Due to heavy body and feeble wings, flight is not possible by the female moth. Its life span is very short 2 or 3 days.





Fig. 3.3 Adult silk moths.

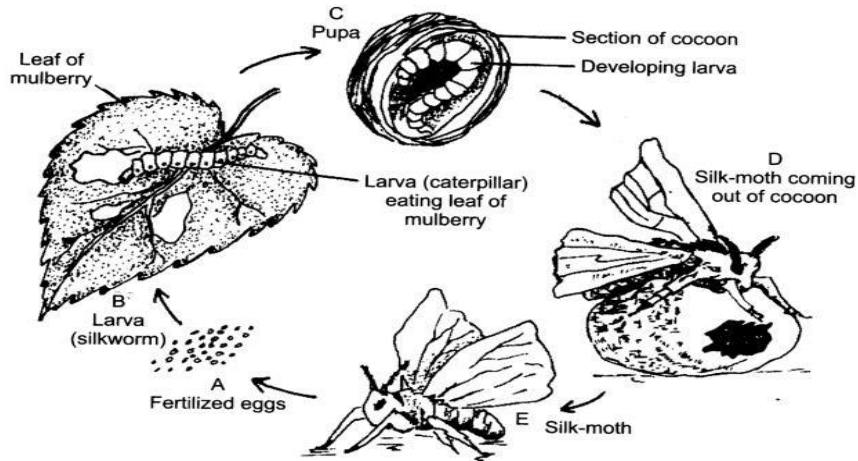
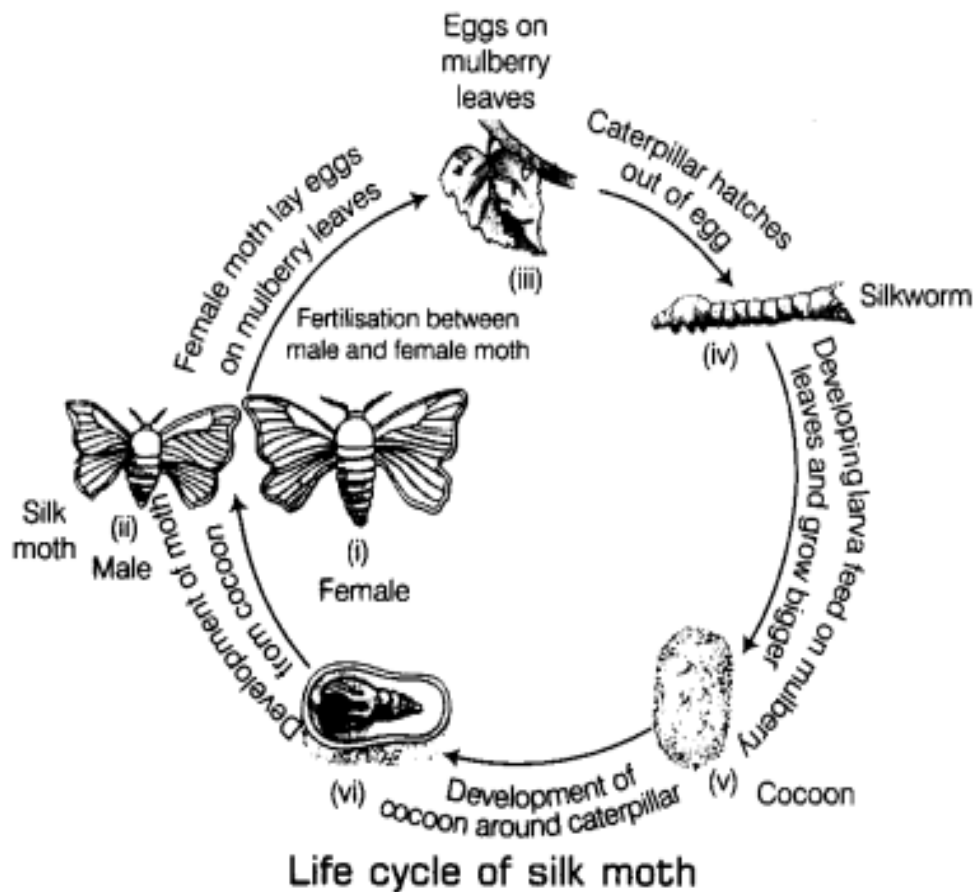
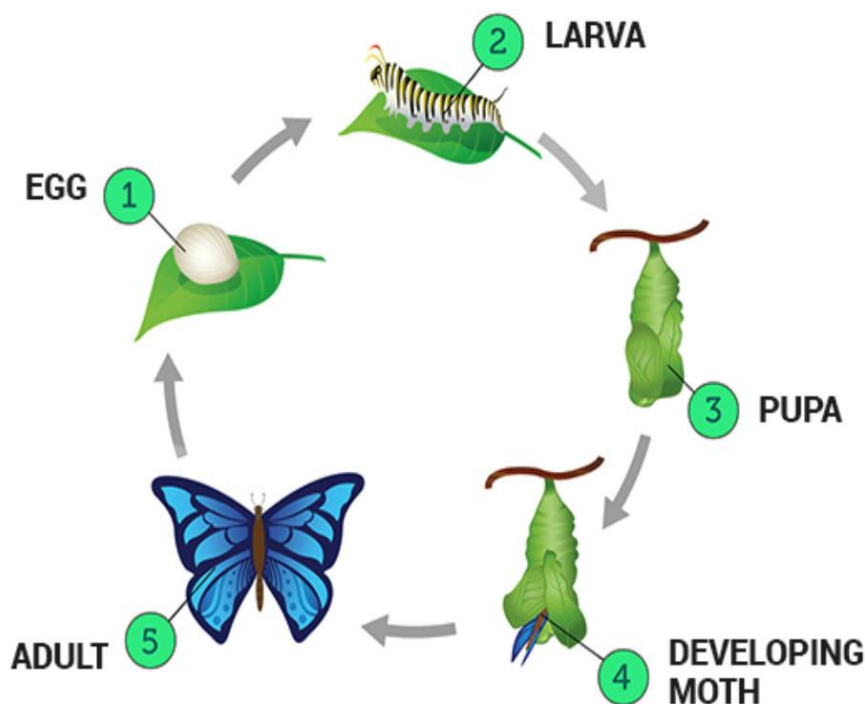


Fig. 3.4 Life-cycle of silk-moth.





## Fertilization :

Fertilization is internal, male copulate female for about 2 or 3 hours and if not separated they may die after few hours of copulating female. Just after copulation, female starts egg laying which is completed in 1-24 hours. One moth lays 400 to 500 eggs depending on climatic conditions and supply of food material to caterpillar. Egg laying is always in form of clusters and covered with gelatinous secretion of the female moth which help them in proper attachment.

## Eggs :

The eggs laid by the female moth are rounded and white in colour. After laying eggs become darker day by day. Two types of eggs are found **Diapause type** and **Non-Diapause type**. Diapause type of eggs are laid by the silk moth inhabiting in temperate regions

whereas silkworm belonging to **subtropical regions like India** lay non-diapause type of eggs.



Mulberry Plant

## Hatching :

The eggs after ten days (10 days) of incubation hatch into the larva called as caterpillar. After hatching caterpillars need continuous food supply for proper development.

## Caterpillar :

The newly hatched caterpillar is about 0.3 cm in length and is pale, yellowish- white in colour. The caterpillar has well developed mouth parts adapted for feed easily on the mulberry leaves.

The caterpillar has twelve segments having the abdominal region has ten segments having five pairs of pseudo-legs. It is also provided with a small dorsal horn on the anal segment. Because of its being very much tender, the Ist instar larva can feed only on very soft leaves of mulberry plants.

After 1st, 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup> moulting caterpillars get changed into 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup> and 5<sup>th</sup> Instars respectively. It takes about 21 to 25 days after hatching. The full grown caterpillar is 7.5 cm in length. It develops salivary gland and stops feeding and undergoes pupation.



## Pupa :

The caterpillar stops feeding and move towards corner among the leaves and secrete a sticky fluid through silk gland. The secreted fluid comes out through spinneret ( A narrow pore situated on the hypopharynx) and takes the form of long fine thread of silk which hardens on exposure to the air and wrapped around the body of the caterpillar in the form of a covering called cocoon.



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## Cocoon :

The silkworm caterpillar builds its cocoon by producing and surrounding itself with a long, continuous fibre, or filament. Liquid secretions from two large glands within the insect emerge from the spinneret, a single exit tube in the head, hardening upon exposure to air and forming twin filaments composed of fibroin, a protein material.

A second pair of glands secretes sericin, a gummy substance that cements the two filaments together. Because an emerging moth would break the cocoon filament, the larva is killed in the cocoon by steam or hot air at the chrysalis stage. Cocoon is the white colour bed of the pupa whose outer thread are irregular while the inner threads are regular.

The length of continuous thread secreted by a caterpillar for formation of cocoon is about 1000-1200 metres which require 3 days to complete. The threads is wound around the cocoon in concentric manner. The binding of threads round the cocoon is very interesting and quick going phenomenon achieved by the constant round motion of the head of the caterpillar from one side to the other at the rate of 65 times per minutes. Now the silk worm pupa is covered within a thick, oval white or yellow silken cocoon.



## Emergence of Imago :

Due to active metamorphic changes during pupal period the abdominal pseudo-legs disappear and two pairs of wing develop. The silk worm within the cocoon secretes an alkaline fluid to moisten its one of the ends and worm released as silk worm.

## Silk :

Silk is the protein secreted by the larvae of certain **Lepidopteran moths**. It is fibrous in nature, and widely used for the manufacture of art clothes. The silk is derived from silk moths mainly belonging to **Bombycidae** and **Saturuidae families of lepidoptera**.

Silk is a continuous filament within each cocoon, having a usable length of about 600 to 900 metres (2,000 to 3,000 feet). It is freed by softening the binding **sericin** and then locating the filament end and unwinding, or reeling, the filaments from several cocoons at the same time, sometimes with a slight twist, forming a single strand. Several silk strands, each too thin for most uses, are twisted together

to make thicker, **stronger yarn** in the process called throwing, producing various **yarns** differing according to the amount and direction of the twist imparted.

Silk containing **sericin** is called **raw silk**. The gummy substance, affording protection during processing, is usually retained until the yarn or fabric stage and is removed by boiling the silk in soap and water, leaving it soft and lustrous, with weight reduced by as much as 30 % (percent).

Spun silk is made from short lengths obtained from damaged cocoons or broken off during processing, twisted together to make yarn. The thickness of silk filament yarn is expressed in terms of **denier**, the number of grams of weight per 9,000 metres (9,846 yards) of length. Silk is sometimes in a process called weighting treated with a finishing substance, such as metallic salts, to increase weight, add density, and improve draping quality.

## **Physical and Chemical Properties of Silk:**

The silk fibre quality and quantity depends on the size and robustness of the cocoon. It is estimated that on an average a cocoon gives silk filament of 600-1200 m. To produce 1 lb. of raw silk about 2300-2600 cocoons are required. In terms of weight about 11 kg., of cocoon' may yield 1 kg., of raw commercial silk and 1.5 kg of waste silk for spinning. The thickness of the silk filament produced by *Bombyx mori* varies from 0.018 mm.

The filaments have great tensile strength (tensile strength of silk 64,000 lb/ssq. Inch and that of iron 90,000 lb/sq. inch) and good elasticity (the silk fibre can stretch one fifth of its original length). These two properties of silk owe much of its excellence as a textile material.

Silk filaments are formed of an inner core of material called **fibroin** covered by another substance called sericin. Fibroin constitutes about 70-80% of the filament. It is an amphoteric colloidal protein of formula  $C_{15}H_{22}N_5O_6$ . Fibroin when heated burns and gives the smell of burned feather. This property is used to distinguish genuine silk from artificial silk. Sericin is also a protein of albuminous nature.

## **Silk Production in India :**

The origin of silk industry is a controversial topic. According to one source the origin is from India during 200 B.C. (Himalayan region). Whereas another view holds that it originated from China. The knowledge of silk production spread far and wide by the passage of time. Today many Western nations along with Japan, Russia, and Persia. Africa and India are practicing the culture and production of silk.

India has the unique distinction of being the only country producing all the five known commercial silks, namely, mulberry,

tropical tasar, oak tasar, eri and muga, of which muga with its golden yellow glitter is unique and prerogative of India.

North East has the unique distinction of being the only region producing four varieties of silk viz., Mulberry, Oak Tasar, Muga and Eri. Overall North East region contributes 18% of India's total silk production.

India is the second largest producer of silk in the world. Among the four varieties of silk produced in 2015-16, Mulberry accounts for 71.8% (20,434 MT), Tasar 9.9% (2,818 MT), Eri 17.8% (5,054 MT) and Muga 0.6% (166 MT) of the total raw silk production of 28,472 MT.

*The demand for superior quality bivoltine silk is increasing in India for domestic consumption as well as value added silk products for the export market. The Ministry of Textiles Government of India and Departments of Sericulture in various states provide technical and financial assistance for enhancing the bivoltine silk production.*

The Govt. of India has constituted a '**Central Silk Board**' to protect the interests of the silk industry. There are many research institutes solely engaged in the R and D projects of silk cultivation and production.

**The major ones are:**

**(1) Central sericulture research Institute, West Bengal, and**

**(2) Sericulture Research Institute, Mysore.**

## Uses of Silk:

Silk is used mainly in the textile industry for manufacturing garments, especially in the making of women's hosiery. Due to the high investment required in the collection and production of silk, use of silk textiles has become rather a status symbol. Silk is also used in the manufacture of cartridge bags, telephone cable insulations, for dyeing, screen printing etc.

## Rearing of Larvae:

Utmost clean lines and hygiene should be maintained while handling the larvae as they are easily vulnerable to infection. The incubator tray containing just hatched out larvae is taken and covered with perforated paper.

Tender and finally cut pieces of mulberry leaves are placed over the paper. The young larvae wriggle out through the pores on the paper and begin feeding on the leaves. Rearing is done in a special room or cabin and the temperature is maintained at 77°F. The larvae are transferred to large wire meshes covered with paper. Along with their increase in size the number of larvae in each tray is reduced to prevent overcrowding.

They feed voraciously and in 4 to 5 days their size double. The feeding phase (larval phase) lasts for about 40 days during which it passes through 4 periods of sleep alternating with 4 moulting stages.

During each moulting the old skin of the larva is shed and a new one formed from beneath.



Silk Reeling

## Production and Recovery of Cocoon:

The fully grown larva exhibits signs to indicate that it is about to begin spinning of cocoon. It lifts its front part of the body and moves it in a circular fashion. Close observation has to be maintained to notice this change. They are now transferred to spinning trays containing dry leaves, twigs and straws.

The caterpillar will release its silk secretion from the silk gland and be gains spinning the silk cocoon around itself. Here again, overcrowding must be prevented, otherwise silk threads of two nearby larvae may get entangled and spoil the fibre. In about 9-11 days the spinning will be completed and the cocoons are collected. The cocoons may be preserved immediately after the spinning is over or else, the chrysalis (pupa) moulted inside may cut the exit hole on the cocoon, which spoils the silk fibre.

The cocoons are suffocated by using steam. They are collected over porous trays and placed over a cauldron containing boiling water. The steam will percolate through the pores of the tray and kill the chrysalis inside the cocoon. The treated cocoons can be stocked for weeks in dry places. The chrysalis dead inside will dry up.

## **Spinning of Cocoons:**

This is the period when the caterpillar stops feeding and starts to secrete a pasty substance from the silk gland. In this condition worms should be picked up and transferred to the spinning trays and kept in a position of slope (slanting) to the sun for a short period. Within three days spinning is over and the cocoon is formed and this is the last phase of the rearing of silkworm.

## **Quality of Cocoon:**

The quality of cocoon is dependent on the raw silk yield, filament length, and reel ability and splitting.

## **Marketing of Cocoon:**

The price of cocoon is fixed during every season of the rearing. This price is, however, watched by the Government and cocoons are purchased by the rears.



## **Post-Cocoon Processing:**

The method of obtaining silk thread from cocoon is known as post-cocoon processing.

### **This includes stifling and reeling:**

#### **1. Stifling:**

The process of killing the cocoons is termed as stifling. Sericulturists should be very much careful that before the emergence of silk worm (The cocoons which do not have cut holes) good sized cocoons of 8 to 10 days old are selected for further processing and dropped into hot water or subjected to steam or dry heat, sun exposure for 3 days or fumigation. In this way pupae or cocoons are killed. The killing of the cocoon in boiling water helps in softening the adhesion of the silk threads among themselves and loosening of the outer threads to separate freely, facilitating the unbinding of silk threads.

#### **Reeling and Spinning:**

The process of removing the threads from the killed cocoon is called as reeling. Four or five free ends of the threads of these cocoons are passed through eyelets and guides to twist into one thread and wound round a large wheel from which it is transferred to spools. Thus the silk obtained on the spool is called as Raw silk or reeled silk. The waste outer layer or damaged cocoons and threads are separated,

teased and then the filaments are spun. This spunned silk is called as 'spun silk.' The raw silk is further boiled, stretched and purified by acid or by fermentation and then carefully washed over again and again to bring about the well-known lustre on the thread.

The modernization of the reeling and spinning process by autolization and various labour saving process has opened a new way to this cottage industry in the world. One autolizer can yield 3.715 kg silk per basin in 8 hours in Japan.

## **Precautions:**

1. Utmost cleanliness and hygiene has to be maintained during sericulture, especially while handling eggs and larvae which are easily prone to infection.
2. Incubation of eggs has many advantages that it helps in simultaneous hatching of eggs, and completion of larval growth, and simultaneous cocoon spinning by the larvae which are useful and economical to the cultivator.
3. Food resource or availability of plant leaves must be assured before beginning the larval rearing.
4. Overcrowding of larvae must be prevented.
5. During diapause and moulting the caterpillars should not be disturbed, which otherwise may lead to death of the worms,
6. The feed leaves should always be maintained moist.

7. Constant inspection of the eggs and larvae for any microbial infection should be carried out. Infected eggs and larvae are to be immediately removed from the culture rooms.
8. Only uncut and complete cocoon shall be used for reeling silk.

## Moriculture :

Moriculture refers to the cultivation of mulberry plants, whose leaves are used as silkworm feed. These plants can be grown via three different methods:

- Cultivation from seeds
- Root-grafting
- Stem grafting

The stem grafting method is the most commonly used method for mulberry plantation. Here, cuttings that are approximately 22 centimeters in length, containing at least 3 buds, are extracted from the stem of a mature mulberry plant. These cuttings may be directly planted or first kept in nurseries and then transplanted.



Moriculture

The mulberry leaves can be harvested from the plants via the following methods:

- Leaf picking – the removal of individual leaves by hand.
- Branch cutting – removal of the entire branch.
- Top shoot harvesting – removal of the mulberry shoot tops.

It is interesting to note that 1 kilogram of mulberry leaves can feed approximately 50 silkworms (from the egg stage to the cocoon stage).

## **Mulberry (*Morus* spp., Moraceae)**

The important character of the members of the family Moraceae (especially *Morus* spp.) is the presence of idioblast, an enlarged epidermal cell in the leaf.

## **Ecological requirements**

### **Climate**

Mulberry can be grown upto 800 m MSL. For the optimum growth of mulberry and good sprouting of the buds, the mean atmospheric temperature should be in the range of 13oC to 37.7oC. The ideal temperature should be between 24 and 28oC with relative humidity of 65 to 80 percent and sun shine duration of 5 to 12 hours per day.

Mulberry can be grown in a rainfall range of 600mm to 2500mm. Under low rainfall conditions, the growth is limited and

requires supplemental irrigation. On an average, 50mm once in 10 days is considered ideal for mulberry.

### **Soil :**

Slightly acidic soils (6.2 to 6.8 pH) free from injurious salts are ideal for good growth of mulberry plant. Saline and alkaline soils are not preferred.



## **Propagation of mulberry :**

- Mulberry is mostly propagated through cuttings.
- Cuttings may be planted straight away in the main field itself or nursery may be raised and the sprouted and rooted saplings may be planted in the main field.

### **Selection of planting material**

- Generally, the mulberry plants are raised from semi-hardwood cuttings.
- Cuttings are selected from well established garden of 8-12 months old.

- Only full grown thick main stems, free from insect and disease damages having a diameter of 10-12mm are chosen for preparation of cuttings.
- The cuttings should be of 15-20 cm with 3-4 active buds and should have 45° slanting cut at the bottom end.
- Care should be taken to make a sharp clean cut at both the ends of cuttings without splitting the bark.
- Manually/power operated mulberry cutter (stem cutting machine) is available for quick cutting of propagation material.

## Nursery

- Select 800 sq.m. area of red loamy soil near water source for raising saplings for planting one hectare of main field.
- Apply 1600 kg of Farm Yard Manure (FYM) @ 20 t/ha and mix well with the soil.
- Raise nursery beds of 4m x 1.5m size.
- The length may be of convenient size depending upon the slope, irrigation source, etc.
- Provide a drainage channel and avoid shady area.



## Planting methods :

**Paired row system :** Plant the cuttings/saplings at a spacing of 75 / 105 cm x 90 cm. Raise intercrops in the wider inter row space (amenable for mechanization also).



## Planting of saplings :

Plant the well rooted and sprouted saplings at a depth of 15-20 cm

- Earth up and level the area around the saplings
- Gap fill during monsoon months



## Methods of Irrigation

### Ridges and furrows method :

- Most efficient method of irrigation
- Comparatively requires less amount of water
- The furrows serve as drainage channels during heavy rainfall.

### Flat bed method :

- Rectangular beds and channels are formed
- Water run off is relatively low

More land is wasted and requires more labour for field preparation



### Drip Irrigation :

- Most efficient in water use
- Substantial saving in irrigation water
- Better crop growth
- Suitable for undulating terrains



- Fertilizers can also be applied along with irrigation water
- Clogging of emitters by physical, chemical and biological impurities
- Initial cost is very high

## Mulching :

Mulching with pruned mulberry twigs and other materials like straw and dried leaves will have the following advantages

- Controls weed growth
- Conserves soil moisture by reducing run-off
- Increases the infiltration of water
- Reduces the soil temperature



## Pruning methods :

(i) **Bottom pruning** : The plants are cut at ground level leaving 10-15 cm stump above the ground. This type of pruning is done once in a year.

**(ii) Middle pruning :** The branches are cut at 40-60 cm above the ground level. After bottom pruning, subsequent cuts are made at 45-50 cm height.

**(iii) Kolar or Strip system :** In closely planted area, this type of pruning is done. The branches are cut at ground level every time. Thus, it receives five prunings every year. This type of severe pruning requires heavy fertilization and irrigation.

## Harvesting:

The method of leaf harvest depends on the type of rearing practiced. It is preferable to harvest the leaves during morning hours. There are three methods of harvesting of mulberry leaves

### Leaf picking :

Individual leaves are harvested with or without petiole. Leaf picking starts 10 weeks after bottom pruning and subsequent pickings are done at an interval of 7 - 8 weeks.



## Branch cutting:

The entire branches are cut and fed to the worms. Before that, topping is done to ensure uniform maturity of the lower leaves.

## Whole shoot harvest :

The branches are cut at ground level by bottom pruning. Shoots are harvested at an interval of 10-12 weeks and thus 5 to 6 harvests are made in a year



## Time of harvest :

It is preferable to harvest the leaves during morning hours.

## Preservation of leaves :

Use leaf preservation chamber or wet gunny bags to store the leaves or cover the bamboo basket with wet gunny bags to keep it cool and fresh

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