Sericulture is an agro-based Industry, the term which demotes Production of Silk through silk worm rearing or in other words commercial production of Silk through silkworm rearing. Sericulture is a labour intensive agro industry ideally eradicate un employment. Further improves their economic standards of rural poor. “Silk” the queen of textiles has a great importance ever before pre Vedic era. The term ‘Silk’ was mentioned in Rig-Veda, Ramayana and Mahabharata. It is estimated that one of mulberry and its allied activates can provided employment to people either directly or indirectly. Sericulture improves frequent returns throughout the year with relatively less expenditure common in puts.
1.2 History

Today there are more than 29 Countries in the world are practicing Sericulture; Historical evidence shows that, silk was discovered in China and later the industry spread to other parts of the world. The earlier reference to silk was found in the chronicles of Chou – King (220BC). The discovery of silk is legend that during 2500BC, one day in the garden. She saw some tiny insects feeding on some kind of leaves. Few days later she found the worms to have grown very big, and the curious queen continued to observe the process till the cocoons were spun by the worms. After the formation of cocoons the queen collected them and preserved till moths have evolved. One day accidentally she dropped some cocoons into hot tea cup, when she tried to remove them from the cup, a fine lustrous yarn came out of the cocoons. Historical evidence reveals that sericulture was practiced in the China long back and preserved the secret for more than 3000 years and the Chinese maintained the monopoly about 3000 years and they built a prosperous silk trade with the rest of world. The Chinese emperor ruled that, revealing of worm eggs or mulberry seed was bound to meet the very severe punishment. However 500 years later there is a reference in mulberry cultivation in ‘Seminyojutu ’ Such as mulberry layings, seed lings. During this period only mulberry cultivation technique appeared to have been taken up very seriously.

1.2.1 History of sericulture in India

According to western historians, mulberry cultivations Spread to Indian about 140 BC from China Through Tibet. The mulberry cultivation and Silk industry first began in the areas Flanking the rivers Brahmaputra and Ganges the Aryans discovered the Silk worm in Sub Himalayan regions even though mulberry cultivation may have come to India from China.

The silk from Kashmir became very famous in the beginning of christen era. This may be the fact that, the Arabs obtained the silk worm eggs and mulberry seeds from India during the early days of christen era. Silk from Kashmir and Bengal was exported to the European markets during the 14th and 15th century, from 1761 to 1785 the export of Bengal silk to the European markets. East India Company started to modernize the silk worm rearing and silk reeling techniques. In 1771, the Chinese Silk was introduced with the object of the quality of Cocoons. Between 1717 and 1775 the Haitian methods of rearing was introduced by East India. The attempt to replace indigenous breeds of Silk
worm by the new varieties of mulberry plant without scientific study eventually is the whole industry to chaos.

During the 19th century the disease called ‘PEBRINE’ wiped out the whole industry in France, this was happened in Bengal too. LOUIS PASTEURS (1870) discovery of the method of mother moth examination could control pebrine disease. A silk conference was called for by the British Govt. in 1942 at Delhi. The Government launched an ambitious project called ‘Silk Expansion scheme’. In 1948 the Country was divided in to India and Pakistan. As result some silk Producing areas have gone to Pakistan and East Bengal. During 4th century AD, when the sericulture industry established in India and central Asia, raw silk and silk goods were exported to Persia and Rome. In 553 AD, Sericulture was spread to Constantinople. Gradually, Sericulture industry developed in venation Republic and was able to meet the entire demand of silk in European by eleventh century. During 19th century when the silk industry was at peak in France, the epidemic of pebrine wiped out the sericulture industry not only in France but also in Europe and Middle East.

1.2.3 Central Silk Board (CSB)

In 1948 an Act was passed by the Indian constituted assembly to set up a ‘Body Corporate’ for developing the Silk Industry on modern lives. As a result CSB Came into Existence in 1949.

1.3 SilkRoad

According to western Historians, mulberry cultivation spread to Indian about 140 BC from china through Tibet. “The fabulous Silk from China and India were carried to European countries all along the 6000 mile long road moving through Bagdad, Tashkent, Damascus and Istanbul. The 6000 miles long lengthy road is historically called the “Silk Road”.

1.4 Silk Production

Today there are more than 29 Countries in the world practicing Sericulture and producing different kinds of silk. India stands second in silk production next to china. Production of silk directly depends up on the area under mulberry cultivation. Today Karnataka stands first in silk Production as well as in the area under mulberry cultivation A.P Stands 2nd in production of raw silk.

1.5 Employment details and Schemes

As said above sericulture is an agro industry, where mulberry is a field based on agriculture activity, Silk worm rearing, Silk reeling, Silk
twisting and silk weaving are the industrial in nature. It has a great opportunity to establish under Self-employment schemes as per the economic standard viz. one can take up (i) 1/2 acre mulberry cultivations and silk worm rearing (ii) 2 basin silk reeling unit (iii) 6 basin silk reeling (iv) 12 basins (v) 24 basins (vi) 48 basin silk reeling units (vii) 60 spindle twisting unit, 120 spindle twisting units 240,360, 720 twisting unit (viii) silk trading (ix) silk export (x) silk dying, like wise a good range of activities.

Opportunities in the industry:

CSB offers different training courses to the candidates sponsored by various state Government. STC, PGDS training courses are offered by Central Sericulture Research and Training Institute, Mysore. These course are open to employees of state sericulture department, NGO’s, Private organizations, unemployed youth / reelers / weavers. Thus a wide range of opportunities are open in sericulture industry.

Highlights review:

- Sericulture is the term which denotes production of silk through silk worm rearing.
- Sericulture is an agro industry of silk.
- The fabulous silk from China and India were carried to European countries along the 6000 mile long road passing through called ‘ the Silk road’.
- Industry is one of the income generating activity not only for the rural formers but also to the educated youth.

Short Questions:

1. What is ‘silk road’?
2. What are CSB and CSR & TI?
3. What sericulture?

Essay Questions

1. Write about history of sericulture?
UNIT 2

Morphology of Mulberry

Structure

2.1 Introduction

2.2 Distribution of Mulberry

2.3 Hybrid Varieties

2.4 Systematic position of Mulberry

Learning Objectives

• After studying this chapter you will be able to

• Understand distribution of Mulberry varieties all over the India and World

• Identify the Male and Female catkins and arrangement of flowers in inflorescence.

• Distinguish between the types of mulberry species and Hybrid varieties. Understand the morphological characteristics of stem, Root, Inflorescence, leaves etc.,

• Collect the specimens and preserved it.
2.1 Introduction

Mulberry trees are perennial, live for number of years either in cultivated or wild conditions. Depending on the type of cultivation the plant is grown as a bush, tree or a middling. The branching nature of a plant is once again influenced by type of cultivation, mode of training, soil fertility, rainfall and environmental conditions. However profuse branches are must for producing more amount of leaf so as to feed silk worms. Since the cost of production of cocoons reflects the efficiency of leaf production, utilization of leaf by silk worms.

The mulberry can be grown under various types of climatic conditions. The climatic conditions and rainfall are favors the luxuriant growth of Mulberry. Mulberry plant is mainly to produce high quality and quantity of leaf for rearing silk worms. The leaf quality has positive effect on the quality of cocoons which directly influence the silk yarn quality. Mulberry leaf protein is the source for the silk worm to bio-synthesize the silk which is made up of two proteins, fibroin and sericin. The nutritive value and palatability of each species / variety of mulberry varies with the age of the leaf, type of cultivation, harvesting methods, and duration of storage, season fertilizer and irrigation schedules.

Thus the success of good quality cocoon yield totally depends upon proper planning and maintenance of mulberry garden / plant. Thus CSB has recommended certain specific mulberry varieties to suit the eco climatic conditions of particular stole / area.

2.2 Distribution of Mulberry

Mulberry plant is distributed all over the world. It can be grown in temperate regions and tropical zone. Mulberry cultivation is adapted Japan, China, S. Korea, Russia, India, Brazil, France, Spain, Greece, Czechoslovakia, Turkey, Sri Lanka, Hungary, Egypt, Syria, Burma, Poland, Thailand, Lebanon, Bulgaria, Cyprus, Vietnam, Bangladesh, Afghanistan, Rumania, Indonesia, Cambodia etc.

The sericulture belt can be divided into two zones in the world I. Temperate, II. Tropical zone. The countries fall under temperature zone producing uni voltine cocoons are Japan, China, Korea, Northern India, Burma, Iran, Turkey, South of Rumania, Lebanon, Greece, Rumania, Bulgaria, Hungary, Yugoslavia, Spain, Italy, France and Poland. The tropical zone stretches from 30th north latitude and contains poly voltine silk worms.
India the only country to produce all the four types of silk viz., Mulberry, Tassar, Eri and Muga 90% of silk produced in India is Mulberry.

Karnataka, Andhra Pradesh, West Bengal, Tamilnadu and Manipur states are at the top under Mulberry area known as Philippine variety. Kadambi (1949) reported that many of the Mulberry varieties were introduced into India from China, Europe, Japan or Philippines.

The classification of Indian varieties is different types in other countries Mukerjee (1899) described. *Morus laevigata* and *M. indica* are the varieties of *M. laevigata* and *M. Serrata* as a separate species and regarded the *M. Laevigata*, *M. Sinensis*, *M. Philippinensis*, *M. Multicaults* and *M. indica* as varities of *M. alba*.

Basing on the principles of classification made by Hotta (1954), Gururajan (1960) adapted all the cultivated forms of Mulberry into three species.

1. *M. latifolia* - This includes mulberry tree grown in U.P. and Kashmir.
2. *M. alba* - This includes mulberry bushes cultivated in Tamilnadu and Mysore.
3. *M. bombycis* - This includes Berhampore variety.

*Morus alba*

Cultivated in Punjab, North, and West Himalayas ascending to 3500 m. The trees grow to height of 10-15 m. and of wild and cultivated for their fruits and timber.

*Morus indica*

Most of the Indian of mulberry belong to this species. They are moderate size deciduous trees, distributed in the lower Himalayan and sub-Himalayan tracts from Kashmir to in the other regions in India, particularly in and Assam in the north east and in southern plateau in Karnataka and Tamilnadu ascending up to 1500M. There are several verities falling under this species, raised mostly as bushes.

*Morus serrata*

This species grows as trees up to height of 20 to 25m with a trunk girth of about 9 mt. In temperate Himalayas from Kumaon Hills west ward, upto an attitude of 3000m.
**Morus laevigata:**

This species is distributed in tropical and regions from Indus valley to Assam wild cultivated ascending to 1500m.

**Fig. 2.1 Mulberry Varieties**

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Character</th>
<th><em>M. alba</em></th>
<th><em>M. nigra</em></th>
<th><em>M. laevigata</em></th>
<th><em>M. latifolia</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bark</td>
<td>Greyish-brown or brown</td>
<td>Brown with a tinge of green</td>
<td>Grey or Greyish brown</td>
<td>Brown or white</td>
</tr>
<tr>
<td>2</td>
<td>Scaly Buds</td>
<td>Brown and triangular</td>
<td>Brown and triangular</td>
<td>Brown and triangular</td>
<td>Brown and triangular</td>
</tr>
<tr>
<td>3</td>
<td>Leaves</td>
<td>Thin, integral and lobate</td>
<td>Integral, rarely lobate</td>
<td>Integral, rarely lobate</td>
<td>Thick, dark green, integral and lobate</td>
</tr>
<tr>
<td>4</td>
<td>Leaf apex</td>
<td>Acuminate</td>
<td>Acute</td>
<td>Long tailed</td>
<td>Acute</td>
</tr>
<tr>
<td>5</td>
<td>Leaf Surface</td>
<td>Lustrous</td>
<td>Scabrous</td>
<td>Scabrous</td>
<td>Lustrous and rugose</td>
</tr>
<tr>
<td>6</td>
<td>Phyllotaxy</td>
<td>5-ranked</td>
<td>5-ranked</td>
<td>5-ranked</td>
<td>5-2 ranked</td>
</tr>
<tr>
<td>7</td>
<td>Idioblasts</td>
<td>Small</td>
<td>Small with projections</td>
<td>Big</td>
<td>Small</td>
</tr>
</tbody>
</table>

1.4 **Hybrid varieties**

Selection of Mulberry variety for a particular region plays an important role. An improved, superior varieties of mulberry are suitable for the existing
environmental and climatic conditions, and soil conditions should be recommended for a particular region.

There are large number of newly evolved and their parental varieties of mulberry are available in germplasm banks.

The popular varieties which are cultivated in different parts of India are:

<table>
<thead>
<tr>
<th>No.</th>
<th>Variety</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Kanva-2</td>
</tr>
<tr>
<td>2</td>
<td>Berhampore local</td>
</tr>
<tr>
<td>3</td>
<td>Mysore local</td>
</tr>
<tr>
<td>4</td>
<td>Sujan pura-1</td>
</tr>
<tr>
<td>5</td>
<td>S1</td>
</tr>
<tr>
<td>6</td>
<td>Sujan pura-2</td>
</tr>
<tr>
<td>7</td>
<td>MR-2</td>
</tr>
<tr>
<td>8</td>
<td>sujan pur-3</td>
</tr>
<tr>
<td>9</td>
<td>Assam bola</td>
</tr>
<tr>
<td>10</td>
<td>Sujan pur-4</td>
</tr>
<tr>
<td>11</td>
<td>Jatinuni</td>
</tr>
<tr>
<td>12</td>
<td>Sujan pur-5</td>
</tr>
<tr>
<td>13</td>
<td>Kutahi</td>
</tr>
<tr>
<td>14</td>
<td>Dhar local</td>
</tr>
<tr>
<td>15</td>
<td>Kotia</td>
</tr>
<tr>
<td>16</td>
<td>Botatul</td>
</tr>
<tr>
<td>17</td>
<td>C763</td>
</tr>
<tr>
<td>18</td>
<td>Botatul</td>
</tr>
<tr>
<td>19</td>
<td>S146</td>
</tr>
<tr>
<td>20</td>
<td>Tsaritul</td>
</tr>
<tr>
<td>21</td>
<td>S799</td>
</tr>
<tr>
<td>22</td>
<td>S-13</td>
</tr>
<tr>
<td>23</td>
<td>Maulanium</td>
</tr>
<tr>
<td>24</td>
<td>S-36</td>
</tr>
<tr>
<td>25</td>
<td>S-54</td>
</tr>
</tbody>
</table>

Fig. 2.2 Mysore Local
Kanka-2 (M5) and Mysore local

These are the two most important varieties. Mysore local grows in rain fed conditions and is drought resistant, can withstand dry climatic fluctuations. M5 is superior variety. It gives lustour leaf yield. The leaves are better quality with more protein content under irrigated conditions, the leaf yield per hectare is 35 MT.
Fig. 2.5 V1

Fig. 2.3 S-34
Fig. 2.6 M5

Fig. 2.7 S-36
Fig. 2.8 S-41

Fig. 2.9 S-30
S-30: It grows in all types of soils. The leaves are bigger in size and more proteinaceous.

The leaf yield per hect / year is 35-38 MT

S-36: Leaves are large. Leaves are heart shaped. Leaves are thick and high quality. More succulent and rich in protein and fiber content. The leaf yield per ha / year is 35-45 MT.

S-54: It can be considered as best of the ‘S’ series. It is suitable for irrigated conditions. It has large leaves, smoothly waxy surface. It has shorter intermodal distance. It has quick sprouting potentiality. The leaf yield under different climatic conditions is superior, leaf yield per hect / year is 37-47 MT.

S-13: It is drought resistant. The plant grows quickly. Leaves are thick, proteinaceous. During summer or drought conditions it supplies quality leaf for rearing the silk worms under irrigated conditions the leaf yield per hect/year is 30-35 MTs and in drought conditions 15-18 MT.

V1: This is the new variety evolved by CSR and TI Mysore. It is suitable for both multi and Bi voltine races. Leaves are big in size, high protein content and more succulent. It has high photosynthetic efficiency. Yield per hect/year is 67 MT it depends on the type of soil, climate, availability of water, specific variety of mulberry for each region should be selected for higher yield.

### 1.4 Systematic position of mulberry

<table>
<thead>
<tr>
<th>Kingdom</th>
<th>Plant kingdom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Division</td>
<td>Phanerogamee</td>
</tr>
<tr>
<td>Sub division</td>
<td>Angiospermae</td>
</tr>
<tr>
<td>Class</td>
<td>Dicotyledons</td>
</tr>
<tr>
<td>Sub clan</td>
<td>Mono chlamydae</td>
</tr>
<tr>
<td>Series</td>
<td>uni sexuales</td>
</tr>
<tr>
<td>Family</td>
<td>Moraceae</td>
</tr>
<tr>
<td>Genus</td>
<td>Morus</td>
</tr>
<tr>
<td>Species</td>
<td>Abla</td>
</tr>
</tbody>
</table>

The following characteristics are found in mulberry plant.
Characteristics of Angiosperms

The angiosperms more commonly known as the flowering plants, are categorized as a group by the presence of vessels in the stem, by the ovule enclosed within one or more capillary sporophylls and composing the ovary, this organs to get with its terminal stigmatic zone constituting.

The basis elements of the gynoecia, the pistil the one or more microsporangia born on a microsporophyll, composing the basis element of the androecium, and the stamens or the combination of members of one or both of these sex elements, accompanied or not by a plinth arising from a common axis, comprise the flower. Subsequent to pollination of the stigma and fertilization of ovules, maturation of capillary tissues occurs with the ovules developing into seeds and the ovary wall into the fist.

2. Class Dicotyledions

The name Dicotyledions owes its origin to the typically two cotyledons present in embryos of members of this class. Plants are herbaceous or woody stems with vascular elements arranged either in a hollow cylinder around the relating small pith. In woody dicot stems the sheath of cambium is situated close to the bark between the xylem and phloem. Leaves, typically with netted venation of the palmate type. Flowers, basically with parts in multiples of 4 or 5.

Sub class: Monochlamydae

Embryo centered round the endosperm, ovule usually one.

Series Uni sexuales: Flowers are unisexual.

Family Moraceae

In Moraceae the inflorescence of each sex is condensed into a pendulous a mentiferous structure. Inflorescence is reduced to globose head. Peduncles have become coalesced and dorsiventrally compressed into a laminated receptacle over. The family is characterized by the presence of milky latex, and single ovule.

Systematic Position

Mulberry belongs to plant kingdom division phanerogammae sub division Angiosperm, dicotyledoris, family Moraceae.

Mulberry belongs to the genus Morus there are 35 spices of Morus. There are more than thousand species of plants belonging to the family
Moraceae. It includes wild and cultivated forms, some of which are sterile. The method of classification of mulberry species should therefore be based on “Genome constituent”, an external characters like leaves, flowers and fruits etc.,

Ledebour (1846-1851) classified Morus alba and M. nigra on the basis of papillae and pubescences on the stigma. While Brandis (1996) classified the mulberry species into two sections by the length of its style. Hoho devided mulberry species into two groups on the shape and situation of cystolith cells in leaves.

In India there are many kinds of spices of which Morus alba, Morus indica, Morus lavigata, Morus serrata are widely growing in Himalayas. The classification of Indian varieties is also much confused. Based on principles of classification adopted by Hotta (1954), Gururajan (1960) suggested varieties of mulberry into three spices i.e Morus alba, (Mysore, Tamilnadu, A.P) M. bombycis (Berhampore vatriety) M. latifolia (Kashmir, U.P).

**Morphology of Mulberry**

Mulberry belongs to the family Moraceae and genus morus. 35 spices show belongs to the genus morus. Each species shows some variations According to Hoocer (1985) the description of the genus morus is as follows.

**Habitat**

Mulberry grows as a tree or shrub, but in cultivation it is raised as bush by pruning. The plant is perennial, with highly branching root and shoot system with primary, secondary and tertiary branches. The branching character varies from type of cultivation, mode of training, rain fall and fertility of soil, upto the height of 22-25 mts. With girth about 8 mts. The bust attains a height of 1.5-1.8 mts which would be ideal for leaf harvest.

**Stem**

The colour of the bark is varies from green, grey to pink or brown. Colour varies and depends upon the species, climate and origin. Mysore local K₂, Berhampore local are white to grayish white in color.

Each axial of a leaf has a bud. Sometime two or more buds on sides are shown and are called accessory buds.

The axillary buds are green which to brown a later stage. The axillary buds of the scale leaves of the main bud peep out of the bud these are called
scale buds. Buds are protected by the covering of young leaves. The growing points emerging as a shoot under favorable climatic conditions. The buds are two types – vegetative and reproductive buds. Like leaves and branches reproductive parts like reproductive buds produce male and female inflorescence in addition to leaves. Winter resisting in buds may be attributed to low temperature, nitrogen deficiency, and investigation of enzymes due to excessive accumulation of carbohydrates during photoperiod. The auxins are responsible for dormancy in bud.

**Leaf**

The leaf size, shapes of Mulberry varieties are different. The hybrid leaves such as Kanva -2, S 54, S 36, S 30, S 34 are characterized by large leaves, while Mysore local bear small leaves. The leaves are simple, alternate, stipulate and petiolate. The stipule protects young leaf, as leaf matures the stipule drops out. The leaf may glossy; texture of the leaf may be entire lobed or rarely of both types are found on the same twig.

The leaf lamina is usually glabrous. The thickness of the leaf is about 100-200mm. The shape of leaf may be cordate or straight and truncate. The leaf tip is acute. The leaf margin may be serrate, dentate. The venation of the leaf is multi costate, reticulate. The leaf surface epidermal cells covered with cuticle and upper epidermal contains idioblast cells. It contains cystolith, non crystalline lime, CaCO$_3$ are present.

**Inflorescence**

In mulberry inflorescence is a catkin more than ten flowers grow around rachis, being attached to the axial of new shoots. This type of inflorescence is called spike or catkin. The peduncle bearing unisexual flowers, the inflorescences is auxiliary.

**Flower**

The male flowers are loosely attached to the peduncles. The flower consists of four perianths, leaves arranged in two whorls with imbricate aestivation. The leaves in transverse plain are in side, they are green, homochlamydous. The margins and other surface of perianth provided with hairs.

The stamens are four, arranged opposite to perianth leaves. The filaments of the stamens are bent inward in bud condition. Each stamen has a broad filament and narrow top on which two anther lobes are fixed, anthers are dithers. The pollen grains are round, dry, light and dust like with smooth
exine. When bud opens, become straightened suddenly and androecium opens with great force and pollens are scattered from the anther. After pollination male catkin becomes pink, dries and drops off as whole. The female flowers also got similar number of parianth leaves arranged in same manner as in male flower. These leaves persist in the fruit the fertilization stimulates the female flower parianth material and contribute to form the fruit.

The ovary is superior, bicapellary, syncarpus. Oval, unilocular, with a single pendulously ovule attached to the margin of the ovary and has a bifid stigma. The length of the style is botanically significant character in identifying various species of Mulberry. The style is long in Dolichostylae and short in Macromorus. After pollination and fertilization the entire inflorescence becomes a multiple fruit.

Pollination

In Mulberry cross pollination takes place by wind. After fertilization the style and stigma fall down and the ovarian wall swells and changes fleshy making fruit. It is called ‘sorosis’. After fruit formation, inner part of the ovarian wall becomes endocarp which shows lignifications and covers seed. The sorosis is green in colour at first and later becomes red and dark purple. The seed in dark purple – colored sorosis gets the ability to germinate effectively. The fruits are ovoid to sub-globules in shape measuring 5 Cm in length.

Seeds

The mulberry seed is oval shaped with flat surface at the micropyle region. On one edge an elongated streak hilum is found. The end of hilum has a small pore known as micropyle through which seed absorbs water when soaked. The seed coat has two layers, outer hard and brittle testa and inner tegma. The seed kernel consists of endosperm and embryo which lies curved in the endosperm. The embryo has a primary axis and two cotyledons. During germination the shoot and radical forms the roots.

The diploid species seeds weight is less than polyploid seeds. The mulberry seeds are available for longer period at low temperature (5°C) and low relative humidity.

Root

The Mulberry root has taproot, lateral roots and root hairs. The hairs are confirmed to top of the root. The root surface has many lenticels. The
root hair absorbs water and nutrients from soil and lateral and tap root's transport and pressure water and nutrients. In general depending upon the soil condition the roots penetrate to a depth ranging from 10 Cm to 50 Cm.

**High lights in Review:**

- Mulberry hardly perennial and deep rooted plant.
- Mulberry belongs to the genus *Morus*. There are 35 spices under *Moraceae* family.
- The classification of mulberry species should be based on 'genome constituents' or external characters like leaves, flowers, fruits, etc.,
- The buds are of two types vegetative and reproductive.
- Leaves are simple, alternate, stipulate and petiolate.

![Fig. 2.10Mulberry Plant](image-url)
Fig. 2.11 Female Catkin  
Fig. 2.12 Male Catkin  
Fig. 2.13 Bud  
Fig. 2.14 LS of Bud  

Foilage leaves  
Scale leaves
Fig. 2.15  A) Male Flower  B) Floral Diagram  C) L.S. of Male Bud

Fig. 2.16  A) Female Flower  B) L.S.  C) Floral diagram  D) Stigma Pubscnt  E) Stigma Papillose

Fig. 2.17  A) Mulberry Seed  B) Side View  C) L.S
Summary

- Inflorescence is a catkin.
- Male flower has four perianth leaves
- Stamens are arranged opposite to perianth leaves.
- Female flower, same condition of perianth leaves after fertilization it becomes thick and juicy.
- Multiple fruit pollination by wind.
- Embryo has primary axis and two cotyledons.
- Root has tap-root, lateral roots and root hairs.

Short Answer Type Questions

1. Name some mulberry species.
2. Draw the structure of mulberry seed.
3. Draw the diagram of mulberry plant.
4. Write classification of mulberry plant.
5. List out some Indian varieties of mulberry.

Long Answer Type questions

1. Write notes on systematic position of mulberry.
2. Narrate morphology of mulberry plant.
3. Describe the systematic position of mulberry.
4. Explain Indian verities of mulberry.
5. Explain about Hybrid verities of mulberry.
6. Write short notes on
   (a) Male flower
   (b) Female flower
   (c) Seed
   (d) Pollination
   (e) Mulberry leaf
(f) Inflorescence

(g) Root

**Numerical Type Questions**

- Collect different types of mulberry varieties and prepare Herbarium.
- Prepare the specimen of male and female flowers, fruits, Root & leaves etc.,
3.1 Introduction (Mulberry Taxonomy)

Taxonomy, one of the oldest fields of biological science, is “the theory and practice of classification”. The earliest systems of classification were
founded on gross structural resembles, such as habit trees, shrubs, vines and herbs. Morphology of the plants is the most widely used instruments of classification in earliest systems.

**Moraceae**

A Family of 53 genera and 1,400 species mostly in the tropical and subtropical regions but a few extend into the temperature zone. More than half of the species belongs to a single genus. In India the family is represented by about 15 years genera and over 150 species occupation mostly in the tropical and subtropical in the layers and Assam. The best known example of Mulberry (Morus Species)

**Classification of Mulberry Plant**

- **Kingdom**: Plant Kingdom
- **Division**: Phenerogamee
- **Sub division**: Angiosperms
- **Class**: Di cotyledon
- **Sub class**: Mono chlamydae
- **Series**: Uni sexuales
- **Genus**: Morus
- **Species**: Alba

**Vegetative Characters**

They are mostly shrubs or rarely herbs and trees also. Tap root with small roots are present.

**Leaves**

The leaves are alternate, rarely opposite, simple, pinnate, palmate and stipulate. The stipules are often caduceus and leave a scar, when they fall off. They are small and lateral forming a cup over the young bud and drop off as the bud unfold.

**Inflorescne and Flowers**

The small flowers are arranged basically in inflorescences which form spikes, heads, disks or hollow receptacles. In Morns the male flowers are arranged in catkins and female flowers a pseudo spikes.
Flowers

The flowers an unisexual (plants monoecious or dioecious) actinomorphic and hypogynous to epigynous. The perianth consists of usually four persistent, free of more or less united petals which are valuate or imbricate in bud. The perianth sometimes absent as in female flowers of some species.

The stamens are usually four, opposite the perianth members. The filaments are inflexed (in mourns). The anther is versatile dithecous and opening length wise. A rudimentary ovary is sometimes present in the male flowers as in Morus.

In the female flower the gynoecium consists of basically two syncarpous carpels. The posterior carpel shows various degree of abortion or rarely is it normally developed. The ovary is superior unilocular with a solitary and pendulous from the apex. The styles are mostly two and filiform. Sometimes rudimentary stamens are present in the female flowers.

Fruits and Seeds

The fruit is a drupe (Morus). The fruit which are enclosed in fleshy perianth are only aggregated (as Morus). The seeds are non endospermic or endospermic and generally with a curved embryo.

Pollination and dispersal

Wind Pollination (Morus).

The bark of M-alba, M-nigra is purgative and vermifuge.

Economic Importance

Morus (Mulberry). The genus has fewer than 10 species in the temperate parts of the Northern hemisphere and in the mountains of the tropics.

The leaves of some species, especially those of M-alba, M-nigra provide food for silkworm.

The fruit of several species like M-alba, M-nigra, M-lavigata, M-serrarta are edible. They are refrigerant and laxative.

Some times M-alba, M-serrata provide wood which is particularly valuable in the manufacture of sports goods.
Fig. 3.1  A-C Morus alba 1. A. Flowering branch with male inflorescences x 2/3  B. Female Inflorescences x 2/3; C. Distillate flower x 6 2/3.

Fig. 3.2
TAXONOMY OF NON MULBERRY PLANTS

The “wild silks” comprise Tasar, Muga, Eri, Anaphe, Fagara, Sinew, Mussel, Spider and Coan. The non-mulberry silk production is mainly by Antheraea mylitta D. A. pernyi, G., A. yamamai, G. (Tasar); A. assamensis, (muga) and philosamia ricini, (Eri). It has also been demonstrated that inter specific hybridization in this genus is possible, Jolly and his associates working at the Central Tasar Research Station, Ranchi.

Although these wild silkworms are polyphagous in nature, there is some preference for food plants. The food plants of first choice are known as “primary” while the others as “secondary”. The salient features of the food plants of non-mulberry silkworm are described hereunder.

Distribution:

Tasar:

The Indian tasar silk industry can be differentiated into three distinct areas viz., (i) Tropical Tasar, (ii) temperate Tasar and (iii) Muga. The tropical tasar is dominated by the host plants, Terminalia and Shorea, the temperate Tasar by Quercus and the Muga by Machilus and Litsaea.

The food plants of tropical Tasar silkworm grow luxuriantly at low altitudes (upto 600 metres above the mean sea level), extending mainly up to torrid zone (23 ½° N and 23 ½° S latitudes) and rather parsley upto 400 latitude in either direction (figure 94).

The genus Terminalia consists of more than a dozen species occurring in Sri Lanka, India, Burma, Laos and Cambodia.

In India T. tomentosa is the most important food plant of tropical tasar silkworm (Figure 96). On topping it shows several shoots which remain weak unless thinned out. Under unfavorable agro-climatic conditions the seedlings take as long as twenty years to grow. This is characterized by its large and oblong leaves and grows at lower elevations in North India, extending up to Nepal, whereas typical, Clarke with elliptic-oblong or ovate leaves is prevalent in south Bihar, Orissa and Madhya Pradesh. There are also a few others which appear to be inter-specific hybrids with T. arjuna.

T. arjuna is a quick growing plant and is commonly found along streams and river beds in Madhya Pradesh and southern Bihar (Figure 95). In respect of leaf quality, this species is considered on par with T. tomentosa. It is also found to occupy the valleys of drier hilly tracts in India, but rarely found in Santhal Pargana, Puri, Cuttack and Balasore. T. catappa is commonly found
to occupy the temperate, humid zones in the sub-Himalayan belt, whereas T.belerica is well distributed throughout India and in the far eastern countries, inside Sal (S.robusta) forests.

The genus consists Shorea consists of half a dozen better known species viz., S.taliura, S.vuulgaris, S.cochinensis, S.thoreli, S.obtusa, S.hypochlora and ., S.robusa. S.robusa is abundant throughout the world and provides a rich base for nature grown tasar cocoons. In India, it is widespread expect the low lying tracts of the Indo-Gangetic plain. It grows at high elevations and also occurs in Puri, Orissa State and other high grounds in coastal areas. When tapped, the tree yields large quantities of a white resin which is used in Hindu religious ceremonies.

Among the secondary food plants the Ber (Zizyphus spp.) is important. This is said to be indigenous to India, Burma and Malaysia. It is widely grown in the plains of Uttar Pradesh, Maharashtra and Rajasthan.

In India, it is grown throughout from Indo-Gangetic plains in the north, extending up to Tamil Nadu in the South.

Sidha

(Lagerstroemia parviflora) is more common India, Burma, Laos, Cambodia and the Republic of South Vietnam. In India it is found all over the sub-Himalayan region, Assam, Bengal, Bihar, Madhya Pradesh, Orissa and Maharashtra, particularly in Poona (Maharashtra); Karnataka, Uttar Pradesh and Bihar. The temperature tasar includes mainly oaks. The genus Quercus, commonly known as oak, comprises nearly 300 species, widely distributed throughout the temperate regions.

In India, the genus is distributed along the western sub-Himalayan range between altitudes of 1200 to 2200 meters and in the eastern hilly tracts between 700 and 1500 meters. The former covers in its stretch the States of Jammu and Kashmir, Uttar Pradesh and Himachal Pradesh, while the latter includes Assam, Meghalaya, Arunachal, Nagaland and Manipur. The oak flora of the former region consists mainly of Q.incana, Q.ilex, Q.glauc, Q.semiparfolia and Q.himalayan where as the flora of the eastern belt are Q.serrata, Q.semiserata and Q.debbata. The foliage of the western flora are early maturing, except that of Q.himalayana, and the foliage of the eastern flora are generally late maturing (Jolly et al., 1974).

3.2.2 MUGA

Som (Machilus bombycina) and Soalu (Litsaea Polyantha), the principal food plants of Muga silkworm grow abundantly in India, Nepal, Burma,
Malaysia and Indonesia. In India, these plants are commonly found in Assam, Meghalaya, Arunachal Pradesh, Tripura, Nagaland, Manipur and North Bengal. Siltimber (Lisaea citrata) another food plant of importance is found throughout the sub-Himalayan belt, West Duras, Khasi hills, Cachar and Dibrugarh. Some plants are classified on the basis of leaf shape.

### 3.2.3 ERI

Castor (Ricinus communis) is believed to have originated from India and Africa. It is grown in many parts of the world such as Sudan, U.A.R., Brazil, United States, Mexico, India, Burma, Sri Lanka, Malaysia, Philippines and Indonesia. In India Andhra Pradesh accounts for about 50 percent of the area under this annual crop, whereas the other important States cultivating this crop are Maharashtra, Assam and Karnataka. Aruna and EB16 are the two important castor cultivars recommended for ericulture. Among others TMV-1, a drought resistant variety W.B.I, a dwarf non-shattering type, M.C.I and Roxy, suitable for red black soils respectively are worth mentioning.

### 3.3 Taxonomy of Primary food Plants

As already stated, Antheraea mylitta, feeds primarily on Asan (T.tomentosa, W&A), Arjun (T.arjuna, Bedd.) and Moru (Q.himjalayan, Bahadur). The golden yellow muga silk is secteted by Antheraea assamensis, Ww, in Brahmaputra valley on Som (Machilus bombycina, King .M.odokratissima Nees.) and Soalu (Litsaea polyantha, Juss), while the brick red or white eri silk is produced by (Ricinus communis, L.) and kesseru (Heteropanax fragrans, Seem.). Being important for the industry, the primary food plants merit elaborate description.

### 3.3.1 Tasar food plants

Terminalia, Roxb. (Figure 96). (Ord Myriales: Fam: Comretaceae). Habit and habitat-large, deciduous tree, leaf, simple, alternate or sub-Opposite, entire, petiolate, often with 1-2 glands on either side. Flower: small, dull yellow, sessile, bisexual, incomplete (Figure 97). Calyx-sepaloid, 5, petaloid, tube produced over the ovary with constricted mouth; Corolla-petal O; Androecium- stamens 5+5, inserted on the calyx tube in two rows; Gynaecium- ovary inferior, pendulous, one celled, ovule-2-3. Fruit 3-6cm long, a coraceous drupe. Seed – exalbuminous, Fleshy, oily. Sprouting-March to June. Fruiting -December to February.
3.3.12 Shorea, Roxb

(Ord: parietals; Fam: Dipterocarpaceae). Habit and habitat: Large, deciduous tree. Leaf- alternate, simple, stipulate, ovate, oblong, acuminate, tough, glabrous and shining when fully mature, entire, lateral nerves 12-15 pairs. Flowers –regular, bisexual, sub-sessile, terminal or axillary racemose panicles. Corolla-petals 5, pale yellow, twisted, much exceeding the calyx. Androecium + stamens numerous, many times shorter than the petals, half perigynous or hypogynous connective sibilate; gynaecium-ovary, 3-celled, style sibilate. Fruit -10-12 cm long, edible, ovoid, acute, fleshy, indehiscent, 5-winged, wings -5-9 cm long, stipulate, narrowed at the base, brown when dry, somewhat unequal with 10-12 straight parallel nerves. Germination- hypogeal. Sprouting –February to March. Flowering– March to April. Fruiting- May to July.

3.3.13 Quercus, L.

(Ord. Fagales, Fam: Fagaceae). Habit and habitat: Large, evergreen, deciduous or sub-deciduous tree. Leaf- alternate, generally serrate. Flower-unisexual, incomplete, monoecious, male generally in drooping spikes(Figure 101a and 101b). Perianth 4-6 lobed, lobes imbricate; Androecium- stamens 6-12 or many, filaments- slender; female- solitary in cluster or short spikes enclosed in involucres of bracts, perianth adnate to the ovary; Gynoecium- ovary 3-5 celled with two ovules in each cell, styles 3-5. Fruit –nut, edible. Seed -1-2, thick, fleshy, cotyledons. Sprouting –May to June. Flowering; April to May. Fruiting; usually in winter season.

3.3.2 Muga food plants

3.3.2.1 Machilus, Nees. (Ord. Laurales; Fam: Lauraceae). Habit and habitat-large, evergreen trees –leaves- alternate, simple, ex-stipulate generally entire, pinninerved, flowers- regular, incomplete, bisexual in axillary and terminal panicles; Perianth-divided to the base, segments-6, imbricate in bud, persistent; Androecium- perfect stamens 9, the 6 outer glandular with 4 celled anthers opening inwards, the inner three with 2 glands at the base and 4 celled anthers opening outwards; the innermost of fourth series of 3 short staminodes, perigynous; Gynoecium-ovary syncarpous, superior, 1-celled ovule-solitary, pendulous, anatropous. Fruit-berry (globose or oblong). Seed-Pendulous, exalbuminous, pedicle not swollen. Seed- exalbuminous. flowering-March to May, fruiting-May to July.
3.3.2.2 **Litsaea**

Lamk. Habit and habitat-large, evergreen trees –leaves- alternate, elliptic ovate, oblong or lanceolate, acute or acuminate. Flowers –dioecious, in few sessile or pedicellate umbels, incomplete, bisexual; perinath-tubular, 4-6 lobed; Androecium- statements-13, those of the inner series with a pair of glands at the base, anthers 4-celled, introse-perigynous; Gynoecium-ovary superior, syncarpous, l-celled, ovule solitary, pendulous. Fruit – drupe. Seed-pendulous, exalbuminous. Flowering –March to May. Fruiting –September to December.

3.3.3 **Eri foodplants**

3.3.3.1 **Ricinus communis, L**

(Vern Bharendra. Ord: Euphorbiaceae, Fam: Euphorbiaceae). Habit and habitat- an evergreen shrub, annuals, biennials, perennials. Leaves- simple alternate. Inflorescence terminal raceme. Flowers- small, incomplete, actinomorphic, hypogynous, unisexual, monoecious, upper female and lower male; perinath in 3-5 whorls, united (Figure 103a and 103b); male flowers – stamens many, polyadelphous; female flowers- carpels–3, united, connate, ovary 3- lobed and 3-celled with one ovule in each cell, styles–3, bifid, long or short stigma-6. Fruit – a globose capsule, generally echinate. Seed, albuminous,. Germination, epigeal. Flowering most parts of the year.

This is an important oilseed crop of India yielding valuable oil and the cake left over after the oil is extracted is used as organic manure. The rainfed crop yields about 2-5q. oil per per ha, where as an irrigated crop yields 5-8q. per ha. When raised for ericulture, the rainfed crop yields on an average 140 q. of foliage and 1-3 q. of seed per ha. Its use in Assam, Meghalaya, Arunchal Pradesh, Manipur and Tripura is mainly for ericulture. In these tracts castor is grown as a self-generated crop on hill slopes, field bunds and other fallow lands, assuming a perennial habit. This is in sharp contrast with Andhra Pradesh, Maharashtra and Karnataka where it is grown as an annual crop, solely for oil, accounting for about 80 percent of total production in India.

3.3.3.2 **Heteropanax fragrans**

Seem. (Vern.Kesseru: Ord. Umbellales / Araliales; Fam: Araliaceae). Habit and habitat- small, erect, evergreen tree. leaves tri pinnate, 2-4ft. long and 2-3ft. wide, petiolate, stipules minute. Leaflets 3-5, ovate or elliptic, short acuminate, narrowed at the base, entire, glabrous. Panicles about 90 cm long, dumbbell bearing racemes, sub - capitates. Flowers- small, yellow, fragrant, bisexual, epigynous, polygamous; calyx-nearly truncate; corolla-

3.4 Secondary food plants

Systematic position

The following secondary food plants of non-mulberry silkworms are considered important:

3.4.1 Tasar

3.4.1.1 Tropical Tasar

Order: Myrtales; Family: Comretaceae.

1. Terminalia chebula, Retz. (Vern. Haritaki);
2. T.beleria, Gaertn. (Vern, Bahera);
3. T.catappa, L. (Vern Janagalibadam);
4. T.Paniculata, Roth. (Vern. Kinjali);
5. Anogeissus latifolia, Wall. (Vern. Dhaunta);

Order: Mytrales; Family: Myrtaceae

6. Syzigium cuminii, Skeels. (Vern. Jamun);
7. Careya arborea, Roxb. (Vern. Kumbi);

Order: Myltrales; Family: Lythraceae

8. Lagerstroemia parviflora, Roxb. (Vern. Sidha);
9. L.indica, Linn. (Vern. saoni);

Order: Myltrales; Family: Melostomaceae

10. a mMelostomalabthricaum, L. (Vern. Phutki);
11. Zizyphus jujube, Mill. (Vern. Ber);
12. Z.rugosa, Lam. (Vern. Bhand)
13. Z.xylopyra, Willd. (Vern. Kathber);
14. *Z. mauritiana*, Lam. (Vern. Indian Ber or Hevi);

**Order: Lamiales; Family: Verbeaceae**


**Order: Malves; Family: Moraceae**

16. *Ficus religiosa*, L. (Vern. Pipal);
17. *F. retusa*, L. (Vern Chilkan);

**Order: Parietales; Family: Dipterocarpaeae**

20. *Shorea tailura*, Roxb. (Eng. Lac tree of S. India);

**Order: Gentianales; Family: Apocynacae**

21. *Carissa carandas*, L. (Vern. Karumcha);

**Order: Gerniales; Family: Meliaceae**

22. *Capadessa fruticosa*, Blume (Vern. Nalbali);

**Order: Rubiales; Family: Rubiaceae**

23. *Canthium didynum*, Roxb. (Vern. Rangruri);

**Order: Sapindales; Fam: Sapindaceae**

24. *Dodanaeae viscosae*, (L.) Jacq. (Vern. Aliar);

**Order: Sapindales; Family: Sapotaceae**


**Order: Roasales; Family: Laguminousae; Sub-fam: Caesalpinadaleae**

26. *Hardwickia binata*, Roxb. (Vern. Anjan);

3.4.1.2 TEMPERATE TASAR (OAK BASED)

**Order: Fagales; Family: Fagaceae**

28. *Quercus aegilops* L. (Valonia oak);
29. *Q. borealis*, Michx.f. (American Red oak);
30. Q. Canariensis, Willd. (Canary Island oak);
31. Q. castaneaefolia, C.A. Mey (Chestnut leaved oak);
32. Q. cerris L. (Turkey oak);
33. Q. cocoinea, Munchh. (Scarlet oak);
34. Q. frainetto, Ten. (Hungarian oak);
35. Q. hispanica, Lam, var. lucombena (Sweet), Rehd. (Eng. Lucombe oak)
36. Q. ilex, L. (Evergreen oak);
37. Q. libani, (Lebanon oak);
38. Q. lustiana, Lam. (Lusitanian oak);
39. Q. Palustris, Munchh. (Pin oak);
40. Q. Petrae, (Mattuschka) Libel. (Sessile oak);
41. Q. reticulatam Humb and Bonpl. (Net-leaf oak);
42. Q. robur, L. (English oak);
43. Q. Suber, L. (Cork oak);
44. Q. semicarpofolia, Smith (Vern. Kharshu);
45. Q. glauca, Thunb (Vern. Inai);
46. Q. acutissima;
47. Q. cripula;
48. Q. mongolica;
49. Q. mysrinaefolia;
50. Q. dentata;

Order: Salicales; Family: Saliceae.

51. Salix viminalis (Eng. Willow).

3.4.4.2 MUGA

52. Litasea cirata, Blume, (Vern. Sittimber);
53. L. salicifolia, Roxb. (Vern. Digloti);
54. Actinodopline sps.
55. Cinnamonum sps.

**Order : Magnoliaceae; Family: Magnoliaceae**
56. Michelia champaca, Linn (Vern. Chapa)

**Ordre: Rhammaceae; Family: Rhammaceae**
57. Zizphus jujube, Mill. (Vern. Ber)

**Order: Geraniales: Family: Rutaceae**
58. Zanthoxylum rhesta DC (Vern. Bajramani);

**Order: Lamiales: Family: Verbenaceae**
59. Gmelina arborea, Roxb. (Vern. Gambari);

**Order: Celatraceae: Family: Celatraceae**
60. Celastrus monosperma, L. (Vern. Bhuroti)

**3.4.4.3: ERI**

**Order: Euphorbiales; Family: Euphorbiaceae**
61. Manihot utilissima, Pohl. (Vern. Simul-Alu)
62. Jatropa curcas, Linn (Vern. Bhotera);
63. Sapium sps. P. Br.

**Order: Geraniales: Family: Simarubaceae**
64. Alianthus excels, Roxb. (Vern. Maharukh);

**Orderily: Geraniales: Fam: Rutaceae**
65. Evodia flaxiniflora. Hook, F. (Vern. Pyam);

**Order: Geraniales: Family: Caricaceae**
66. Carica Papaya, L. (Vern. Papita);

**Order: Gentianales: Family: Apocynaceae**
3.5 Foliar constituents of Tasar food plants

Chemical analysis of the leaves reveals useful information on the nutrition values of food plants of silkworms. This paves the way for selection of suitable food plants species and their varieties and also the appropriate stage at which the leaves are to be harvested. The foliar constituents in a number of tasar food plants have been assayed at the Central Tasar Research Station, Ranchi, and the data are summarized in table.

Fig. 3.2 T.Tomentosa

There exists considerable variation among the food plants in their nutritional constituents. The total nitrogen and crude protein of the leaves increases with age, whereas the stretch and total sugar contents in most of the food plants get reduced with maturity. It may further be inferred that Asan and Arjun, which have low percentage of crude fibre, together with high percentages of sugars and minerals add to nutritional qualities of the leaves resulting in better tasar silk production.

Climatic Conditions Required for Mulberry Growth

Introduction

Mulberry is a hardy perennial deep rooted plant. It grows in a wide range of environment. Mulberry can grown both tropical and in temperate region. It can be cultivated in different types of soils. Mulberry can be raised in rain fed and irrigated conditions. This plant is comparatively resistant to environment fluctuations.
The growth of mulberry and its leaves are affected by various environmental factors neighboring tobacco fields, factories, buildings, wood. Nicotine from the tobacco plants often contaminate the mulberry leaves and poison the silk worms. Agricultural chemicals used to control the pests and disease of crops in neighboring fields affect the mulberry plantations as the silkworms fed by such leaves are highly susceptible to toxic effects.

In temperate climate woods and buildings to north of plantation prompt sprouting of buds, and thorn in windward position serve as wind breakers where as when located on the south east or south west Linder the plantation from sunshine and consequent reduction in leaf growth.

Thus environmental conditions had a great influence on the growth of mulberry plants climatic conditions.

As mulberry grow in tropical as well as temperate regions. But the mulberry growth differs from place to place as the environmental conditions vary.

There is a close relationship between the growth rate and development of mulberry and external environmental conditions viz., light, air, water, temperature and soil conditions.

The following factors influence the growth of mulberry.

a. Light (sunshine)
b. Temperature
c. Air
d. Rainfall
e. Atmospheric humidity.

Light (sunshine)

Mulberry grows luxuriantly in the presence of sunlight. Mulberry requires lot of light in a day for its normal and healthy growth in the tropical zone like India. In tropics mulberry grows in the sunshine range 9.0-13 hrs a day whereas in temperate countries mulberry grows with a sunshine range of 5.0-10.2hrs a day.

Light is the energy source for mulberry to perform the photosynthesis. There is a close relation ship between the light and quality and quantity of
leaf. Bright succulent shiny mulberry leaf with high nutrient quality can be observant from plant grown under sunlight.

The light receiving capacity of a mulberry plantation depends on the sunshine of mulberry leaf. However, the light energy that is utilized by the leaf is only about 2-3 years of the total light failing to carry out the photosynthesis and most of the light energy absorbed by the plant is converted into heat energy and other radio active energy, when the temperature is 30°, a sunny days production rate of photosynthesis is 2mg (dry matter) per 100cm\(^2\) an hr, and rainy days is only 30% of that of sunny day’s where as during cloudy days is half that of a sunny day.

Therefore, before establishment of a mulberry garden, site selection should be made where sunlight is not a problem. Proper spacing between the plants will allow the sunlight to full on every plant; close plantation restricts the illumination of light on the plant parts. Thereby photosynthesis effects and production of poor quality leaf results. Hence light is an essential factor in mulberry cultivation.

**Temperature**

The optimum temperature for mulberry growth is 24°-28°. At low temperature below 13° c and above 38° temperature the sprouting of buds and growth of mulberry is effected.

In temperate regions sprouting starts during April (spring). The dormant season for the growth of mulberry is November to March. Where as in tropical regions, this problem does not arises. The Mulberry growth continues throughout the year.

Mulberry plant growth starts when its root system begins strengthening its absorption of water and minerals from the ground. When the temperature is above 5°c, winter buds begin to sprout only when the air temperature is above 12°c. The growth becomes more actine as the temperature is above 40° respiration becomes less intense and more food is consumed than is made in photosynthesis. The damage occurs to the growth of mulberry. It becomes less active in its growth; this damage will not be serious if abundant water is available in soil.

During winter mulberry growth is slow as the temperature gradually falls down. The plant growth enters into dormancy if the air temperature drops to 12°c. During this period the plant strength their ability to resistant cold by transforming the starch stored in the plant into sugar and raising the density of cell sap and viscosity of protoplasm. During spring when the
mulberry sprout, the plants are susceptible to frost bite since their ability to resist cold weakness because the concentration of cell sap and viscosity of protoplasm apparently lower. Hence, late sprouting varieties are advisable to the regions where later frost is possible. But mulberry growth is possible throughout the year.

Air

Air is also important element for life activity of mulberry plant. Shortage of oxygen in the soil interferes with respiration of mulberry plant. Where there is a water logging soil is cultivated for mulberry. The growth of plant will be very poor. This is because of poor air retaining capacity of soil. The root system lose its respiratory system. Air contains about 21% of oxygen, owing to poor soil structure, excess of water in soil or consumption of oxygen by respiration of root system by oxidization of minerals and also by activities of micro organisms, said content of air in soil becomes less. Aeration in soil can be improved when the soil is properly cultivated. Coal smoke, dust, steam released by factories, fog in air and poisonous chemicals in minute quantities when adhere to the surface of mulberry leaf, the leaf surface cannot receive the sunlight and respiration becomes obstructed. Hence air also plays an important role in mulberry crop production.

Rainfall

In India rainfall is not uniform in all the parts of country. Rainfall reaches maximum in Assam and minimum in Rajasthan. The mulberry can be well grown with in a range of 600mm to 2500mm. In an average 150mm of rainfall once in ten days is sufficient for ideal growth of mulberry plant. A rainfall ranges from 600 to 2500mm per annum is considered ideal for mulberry. On an average 50mm rainfall once in ten days is considered ideal for mulberry.

Water had an important role on the mulberry plant growth, absorption, photosynthesis, transpiration of food, maintenance of turgor pressure of cells in plant. All the above activities are not only carried out by water but also essential.

Water

Water plays an important role in plant growth of mulberry. Mulberry plant required as much of water as that paddy or other similar crops. It requires only 280-400ml of water to synthesis 1gm of dry matter. The quantity of water required is not contrast it changes greatly with change in soil condition and climatic etc.
On the other hand too much of water in soil is also not good for mulberry growth. But planting mulberry in water logging soils is not advisable. In such soils, short of air can be absorbed. It results affects the root breathing, consumption of nutrients increases, there by root system damaged, according the plant growth hinders.

Mulberry plant contains 60% water. This is distributed into leaf blades (70-75%), root system (54-59%), branches and twigs (58-61%) and the dormant buds (45%).

Atmospheric Humidity

65-80% of atmospheric humidity can be considered as ideally suitable for mulberry growth. The quality of leaf produced during rainy seasons. This is because of higher moisture content available in the soil and higher rate of atmospheric humidity.

Physical Conditions

The most important factor that decides the productivity and profitability in sericulture industry is maximization of quality of mulberry leaf in a given area. Therefore care should be taken in the establishment of mulberry garden. Certain important factors which are considered to be establishment of Mulberry garden as follows.

a. Soil
b. Elevation
c. Latitude and Longitude

Soil

The root system of mulberry plant is greatly influenced by the conditions of soil. All types of soils are suitable for mulberry growth. The PH of soil is ranging from 6.2-6.8 reveals healthy growth of mulberry.

Elevation

In tropical conditions of India, the mulberry is cultivated at altitudes between 300-800m above MSL. Range up to about 700m about MSL is considered for luxuriant growth of mulberry.

Latitude and Longitude

Most sericulture countries are lying north of equator except Brazil which lies south of their equator i.e., 14°-33° southeren latitude in sericulture
belt runs mainly parallel to the tropic of cancer extending up to 50° normal latitude (NL). Thus, dividing two areas namely temperate and tropical zone.
High Lights in Review

- Mulberry belongs to Moraceae family, it includes 1400 species mostly in tropical and sub-tropical zones.

- Shrubs herbs and small trees. Trees stem portion which are used in sports goods industry.

- Leaves and alternate, rarely opposite, simple, forming cup over the young leaves. Those leaves are primary food for silkworm.

- Inflorescent are catkin. Male and female flowers are separated.

- Fruits are drupe and fleshy. Seeds are endospermic and Non-Endospermic with curved embryo.

- Any climatic condition mulberry will be grown but light is more important for photosynthesis 2.0-10.2 hrs/day light is optimum.

- 24°-28°C and average rainfall is 50mm. /once in 10days and atmospheric humidity is 65-80% is necessary.

- 700m above MSL is necessary. 14°-33° latitude and is necessary for good growth of Mulberry.

Questions

Short Answer Type Questions

1. What is the planting season suitable for Mulberry?

2. Write classification of Non-Mulberry Plants.

3. Write classification of Mulberry Plant.

4. What is meant by climatic conditions?

Long Answer Type Questions

1. Write detailed description of Moraceae Family with example of Morus Plant.

2. Write notes on Euphoribaceae family with help of Caster Plant.

3. Write notes on climatic conditions required for mulberry cultivation.

4. Write Taxonomy of Terminalia arjuna (Non-Mulberry plant).

5. Short Notes
Sericulture


Numerical Questions

- Collect the Mulberry plant (Twig) and study the Family Moraceae characteristics.
- Section the T.S of Bud of Male and Female flowers and identify the arrangement of Petals, stamens and stigma and ovary etc.
- Draw the Floral diagram of Male and Female flowers.
- Collect and preserved Male and Female catkin.
- Collect the Mulberry Seeds.
- Prepare herbarium of Male and Female inflorescence.
Structure

4.1 Introduction (Soils)
4.2 Types of Soil
4.3 Soils of Andhra Pradesh
4.4 Properties of Soil
4.5 Selection of Land
4.6 Layout of Plantation
4.7 Land Preparation
4.8 Soil Erosion and Control Methods
4.9 Soil, Moistures Conservation

Learning objectives

• After completing this chapter you will be able to;
• Explain types of soils, soil structure and properties of soil.
• To understand the selection, preparation of soil.
• To learn about soil erosion and soil moisture conservation.
• Identify the color and different chemical properties of soil.
• To learn about in Indian and A.P soils.

4.1 Introduction (SOILS)

Soil is defined as “a thin layer earth’s crust which serves as a natural medium for the plant growth”. Soil is different from parent material from which they developed. Thus they differ in morphological, physical, chemical and biological properties depending on the differences in the genetic and environmental factors. Soil serves as a reservoir of nutrients.

Structure and functions of soil

In plant growth system soil is formed by various components such as minerals, organic matter, water and air, micro organism soil particles and soil. These features depend on the parental material. There are three main kinds of rocks (i) igneous rocks (ii) sedimentary Rocks (iii) metamorphic rocks. Igneous rocks are formed by cooling, hardening and crystallizing of various kinds of lava and differ widely in their chemical composition. The proportion of quantity, 60-75% forms acidic and 50% results in basic soils.

Sedimentation rocks are formed from igneous rocks by consolidation of fragmentary rock material and decomposition products. Metamorphic rocks result, from either igneous or sedimentary by the action of intense heat and pressure to bring out considerable change in texture and mineral composition.

Functions of soils

Soils stores nutrients and water. It provide mechanical strength to the plant. Soil contains minerals, organic matter, water, air, micro-organisms and soil particles etc., soil environment is essential for germination, growth and yield of the plant.

4.2 Types of soils

Soils many be classified based on the texture, color, permeability and several other characters. Rocks are the chief sources for the parent materials over which soils are developed. There are three main kinds of Rocks (i) igneous rocks (ii) sedimentary rocks (iii) metamorphic Rocks. The main constituents of the soil depend on parent rocks. Thus structure, physical and chemical characters are not similar. The Indian soils are classified into nine groups.

1. Alluvial soils
2. Black soils
3. Red soils
4. Laterite soils
5. Saline and Alkaline soils
6. Acidic soils
7. Forest soils
8. Arid and Desert soils
9. Peaty and Organic soils

Soils of Andhra Pradesh

1. Red soil:
   2. (i) Dubba Soils
   (ii) chalka Soils
   (iii) Sandy – Clay soils
   (iv) Deep Clay Soils
   (v) More deep Sandy Clay soils
3. Black soils
4. Gangetic soils
5. Delta Genetic soils
6. Saline and Alkaline soils
7. Costal sandy soils

4.2.1 Alluvial soils or Indo- Gangetic Alluvial

The alluvial soils are formed by the deposition of silt by rivers. These soils are the most important soil group of India, contributing the largest share of agriculture wealth of our country. These soils occupy an area of 3 lakh square miles. The soil color is generally grey and light brown or yellow. These soils are derived by the tributaries of the Indus, the Ganges and the Brahmaputra. The alluvium of these soils is of two types. The newer alluvium is generally sandy, light colored while older is more clayey and dark with full of kankar. The soil texture is sandy loam to clay loam. The soil pH is 7-8. Calcium content is high in these soils. Soils of Uttarpradesh, West Bengal posses’ kankar layers. Soils of West Bengal show variations, Iron oxides cause formation of hard pans in these soils. The soils of Assam are acidic.
while Brahmaputra is sandy. Nitrogen, Potassium, Phosphorus depositions are characteristic of these soils. In Orissa sandy soils are with fine texture with sufficient potassium content but not enough phosphorus. The soils of Bihar are sandy loam to clayey loam and neutral to alkaline. They are rich in total available potash but are deficient in phosphorus. The alluvial soils of Tamilnadu are found in the deltaic areas all along the coastal regions. The soils are heavy throughout the texture ranging from clay loam to heavy clay through silty clay. The Gujarath soils are fairly deep, poor in organic matter and nitrogen, but rich in phosphorus and potash. In Madhya Pradesh the soils are light sandy red and yellow. The majority soils of Punjab and Haryana are loamy or sandy loam of varying depth. The soils are alkaline due to the presence of sodium and other soluble salts in considerable amounts, are lacking nitrogen but phosphorus and potash are sufficient.

4.2.2 Black Soils

This type stands second occupying two lakh square mile area. These soils vary in depth from shallow to deep and characterized by deep color or dark brown. The typical soil derived from the Deccan trap is black cotton soli. These soils are common in Maharashtra, Central Western parts of M.P., southern districts of A.P., parts of Gujarat, and Tamilnadu, northern districts of Karnataka a states of India.

These soils are very heavy with 65-80 percent fine grains and have 6l high degree of fertility. Calcium and magnesium carbonates are in high proportion. They contain 30 percent iron, high quantities of lime, magnesium and aluminium but poor in phosphorus, nitrogen and organic matter. Potash deposits are adequate. The pH of these soils is 8.5. Sand content is very less and these soils Form clay soils. The soil is characteristic in absorbing water and enlarges while radiation causes cracks during summer season.

4.2.3 Red Soils

These soils occupy two lakh square miles. These are generally characterized by light texture with pores and friable structure. Red color is due to the presence of iron oxides which are formed in the soil or from stones of earth layers. It is called red fertile soil, red sandy soil or red gangetic soils. These red soils are formed from granites, shales, quartzite stones. Lack of calcium and less soluble salts are characteristic features of these soils. The amount of nitrogen, phosphorus, potash is less. Morphologically red soils are grouped into two (i) red loams (2) red earths. These soils are found in Tamilnadu, karnataka, Goa, Daman and Diu, south eastern of Maharashtra, east Andhra Pradesh and Madhya Pradesh, Orissa, Bihar, Birbhum district of West Bengal and some districts of Uttar Pradesh.
In Tamilnadu these soils are rather shallow, open texture with pH ranging from 6.6 to 8. They have low base status and exchange capacity is low. Deficient in organic matter and poor in plant nutrient. In the eastern tract of Karnataka the red soils are predominant. Rich in total potash and contain sufficient amounts of phosphorus but very poor in nitrogen. Red loamy soils are in Shimoga and Hasan districts. Iron and aluminium are nearly 30-40 percent. Red soils are acidic in south Bihar with pH ranging from 5.0 to 6.8. In Telangana districts of A.P. red and black soils are predominant while the former are sandy loam.

### 4.2.4 Laterite and Lateritic Soils

Laterite soils are derived from the atmosphere weathering of several Types of rocks. The soils are mixture of hydroxides of iron, aluminium with small amounts of magnesium-oxides. The soils are with good texture and can not store moisture and water, the pH is 5-6. These are found in Karnataka, Kerala, Madhya Pradesh, Eastern Ghats of Orissa, Maharashtra, West Bengal, Tamilnadu and Assam. These soils are deficient in nitrogen, very poor in lime and magnesium and occasionally in phosphorus and potassium. Lateritic soils are red with gravel

And found in high level areas. These are very poor fertile soils. Soils existing in Low level are dark in color with high humus, and texture but do not store water. These are found in costal Andhra Pradesh.

### 4.2.5 Saline and Alkaline Soils

These soils are formed as a result of accumulation of soluble salts in the root zone. The salts mainly consist of chlorides and sulphates of sodium, calcium and magnesium. These soils are found in black soil areas (south and west) sindhu - Ganga deltas, north coastal, west-east areas. The soil pH is 8.5. Soils with white encrustation of salts are called white alkali. If such soil contains more sodium salts, it is called alkaline soil. These soils have an exchangeable sodium percentage more than 15 and with pH more than 8.5. Such soils have low filtration rate and physical condition is unfavourable for cultivation. Because high alkalinity resulting from sodium carbonate the surface soil is discolored and becomes black and called black alkali. Saline soils develop in low rainfall regions. These soils cause low yields crop failures in extreme conditions.

#### 4.2.5.1 Reclamation

a. The salts accumulated at the root zone should be leached below the root zone into the deep layers.
b. Gypsum is used for calcium salts. The quantity of gypsum to be used depends upon the degree of alkalinity. At least 10 metric tons of gypsum should be applied to one hectare and ploughed deeply and irrigated to drain.

c. Alkalinity can be reduced to some extent by application of green manures and deep ploughing.

d. Sulphur is given at the rate of 2 to 4 tons per hectare for reclaiming alkali soils with calcium carbonate.

4.2.6 Acid Soils

The acidic content is more in these soils with pH than 7.0. These soils occur widely in Himalayan region, in the coastal plains of Gangetic delta. In humid regions where rainfall is high the soluble bases formed during weathering of rocks leached down and carried away by the drainage water. The continued leaching results in the replacement of calcium, magnesium, potassium and sodium sulphur, by the hydrogen ions, thus acid soils are formed with low pH. The acidic soils are injurious to plant growth. The availability of some nutrients especially phosphorus, calcium and magnesium becomes low with increasing acidity. Soil microbiological activities are adversely affected as the acidity increases.

4.2.6.1 Reclamation

Acidic soils are neutralized to restore natural characters. Deficiency of calcium in the soil causes damage to root tips and branches. Therefore lime is added at the rate of 100 kg/hectare to increase the pH to 6.5 - 7.0. Acidic fertilizers, Ammonium Sulphates are not used.

4.2.7 Forest and Hilly soils

These are of two types (1) formed under acidic condition with presence of acid humus and low base status, (2) formed under slightly or neutral condition with high base status. These soils are found in all forests. The hilly districts of Assam show a high content of organic matter and nitrogen. This may be due to the virgin nature of the hill soils. The hilly soils in coorg are deep and one of high fertility. The soils of Darjeeling district have well decomposed humus and mineral soil in the surface layer. These soils are strongly acidic in reaction. The temperature and humidity are high in these brown color soils.

4.2.8 Arid and Desert soils

The Rajasthan deserts are occupying 40000 square miles. These sandy soils containing high percentage of soluble salts with pH ranging 7.2 - 9.2.
These are poor in organic matter. The limiting factor of the soils is lack of water. Though the Rajasthan desert on the whole is sandy tract, the soil improves in fertility from west and northwest to east and north east. In many parts the soils are saline or alkaline with unfavorable physical condition. The soils may be reclaimed by proper irrigation facility.

4.2.9 Peaty and Organic soils

These soils are generally submerged in water during the monsoon. As a result of accumulation of large amounts of organic matter in the soils these soils exist. These soils are black, heavy, and highly acidic and contain 40 percent of organic matter, but poor in lime. The depressions formed by dried river basins and lakes in coastal areas sometimes give rise to peculiar water logged and an aerobic conditions of soil. Soils of these places contain varying amounts of organic Matter which are found in the coastal tracts of Orissa and in the Southeast of Tamilnadu.

4.3. Soils of Andhra Pradesh

The above detailed soils are found in Andhra Pradesh. Among which alluvial soils, black, red soils are more. The remaining soils are as follows.

4.3.1 Red soils

It amounts to 65 percent of cultivated soil.

4.3.3.1 Dubba soils

These are formed from coarse granite. These are deep sandy clay to more coarse sandy clay soils. The clay content increases as the depth increases, which Support transport of water. These types of soils contain very less amounts of nitrogen, organic carbon and more potassium.

4.3.1.2 Chalka soils

This red, sandy; clay soils are low depth which form a very hard layer on the surface. It has 10cm small stones, pebbles with dry soil. It contains less nitrogen, moderate phosphorus high amounts of potash.

4.3.1.3 Sandy-Clay Soils

These are found in low level possessing more clay thus stores more water. The sub-soil part has little clay, calcareous gravel, calcium clots. This soil has sufficient potash and less amounts of nitrogen and phosphorus.

4.3.1.4 Deep Clay Soils

These are similar to sandy clay soils but the depth is 90-18 Cm. Soil
structure favour easy and fast transport of materials. But presence of clay on the surface, transport is difficult. These are found in Karimnagar forests, East, West Godavari and Araku Valley.

4.3.1.5 More Deep Sandy Clay Soils

These confined to Karimnagar, Medak, Krishna, Godavari districts. These are deeper than 120 Cm. Presence of clay is more pronounced in depth. Soil stores water. It has less nitrogen, moderate phosphorus and more potash.

4.3.2 Laterite, Lateritic Soils

These red soils are formed in warm humidity, climatic zones with good rainfall and drainage features, found in Medak, Rangareddy, Nellore, Prakasam, Visakhapatnam to a little extent. The texture is light but improves as depth increases. The soils are slight acidic can be corrected with calcium. Soils possess very less nitrogen and phosphorus but produces good yield.

4.3.3. Black Soils

It includes 25 percent of cultivated soils. The soil texture is sandy clay to clay with pH ranging from 7.5 to 9.0. These are classified into shallow, medium, deep black soils based on depth. Water storage capacity is more. Water percolation, transport, drainage features are very less. Calcium content is more. Nitrogen, potash, phosphorus are present. These soils are found in all parts of the state.

4.3.3.1 Combined Red-Black Soils

The combined soils are confined to Telangana. Red Soils are found in bunds of low, high level regions. Small soil particles are drifted towards lower level thus sloppy land has red and black soil. The features are similar to red and black soils.

4.3.4 Gangetic Soils

These are found on the banks of Krishna, Godavari Rivers. The soil properties are based on the alluvials. The texture is muddy. Soils are neutral to basic in nature. These soils are less nitrogen, moderate phosphorus and high amounts of potash.

4.3.5 Delta Gangetic Soils

These Gangetic soils are found near the sea where Krishna, Godavari Rivers join in. These are with high clay and basic features with least drainage
capacity. These soils can be well utilized after proper drainage. Soils are highly productive.

4.3.6 Saline and Alkaline Soils.

These are found in sea banks, useless for cultivation.

4.3.7 Coastal Sandy Soils

Soils are formed in sea shores. Soils possess macro pore space with no water and nutrients. Saline soils are with brackish water.

4.4 Properties of Soils

Productive soils are one which contain adequate amount of all essential elements readily available to plants. They are to be in good physical condition to support, and contain water and air for desirable root growth. The soil must supply all the necessary elements to the plants every day. The constitution of the soil, soil structure, texture, and pH brings about a great difference among the contents of water, air, nutrients to influence upon the growth of roots and shoots of mulberry trees. In view of the above factors one must have through knowledge about the properties of soil.

4.4.1 Physical Properties

Mulberry trees are perennial and deep rooted plants, therefore, physical properties of soil are important for the growth. The following are the essential points for soil of mulberry cultivation.

a. The permeability of air and water through the soil particles must be suitable for the active function of mulberry roots.

b. The retention capacity of water in soils during the dry season is necessary.

d. The air supply to mulberry roots grown in the deep layer of soil must be kept even in the rainy season.

4.4.1.1 Soil Texture

It indicates the relative percentage of coarse and fine soil particles. The soil particles vary in shape and size. The following is the classification of soil particles on the basis of their size.

The soils are identified as light, medium, heavy on the basis of their texture.
The simplest method of determining the soil texture in the field is submoist (not wet) between the thumb and the fore-finger. With a little experience it is possible to determine approximately the relative proportion of sand, silt and clay.

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>CLASSIFICATION</th>
<th>Diameter of the Particle (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Stone</td>
<td>10-100 and above</td>
</tr>
<tr>
<td>2</td>
<td>Gravel</td>
<td>3-10</td>
</tr>
<tr>
<td>3</td>
<td>Fine Gravel</td>
<td>1-2</td>
</tr>
<tr>
<td>4</td>
<td>Coarse Sand</td>
<td>0.5-1</td>
</tr>
<tr>
<td>5</td>
<td>Medium Sand</td>
<td>0.25-0.5</td>
</tr>
<tr>
<td>6</td>
<td>Fine Sand</td>
<td>0.02-0.2</td>
</tr>
<tr>
<td>7</td>
<td>Very Fine Sand</td>
<td>0.05-0.1</td>
</tr>
<tr>
<td>8</td>
<td>Silt</td>
<td>0.002-0.05</td>
</tr>
<tr>
<td>9</td>
<td>Clay</td>
<td>Less than 0.002</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>General Terms</th>
<th>Basic Soil Texture</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Common Name</strong></td>
<td><strong>Texture</strong></td>
</tr>
<tr>
<td><strong>Sandy Soil</strong></td>
<td>Coarse</td>
</tr>
<tr>
<td></td>
<td>Moderately Coarse</td>
</tr>
<tr>
<td><strong>Loamy Soils</strong></td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td>Moderately fine</td>
</tr>
<tr>
<td><strong>Clayey Soils</strong></td>
<td>Fine</td>
</tr>
</tbody>
</table>
4.4.1.2. Soil colour

It is due to the presence of mineral or organic matter or both. Uniformity in nomenclature of colour is possible by comparing the soils with the “Munsell Colour Chart” containing standard colours. It has 8 cards to identify 223 colour clips.

4.4.1.3. Soil temperature

The temperature of soil is influenced by its colour. Dark soils absorb more heat than those of light soils. This character needed for seed germination and root growth. Thermston or Thermocouples are useful for measuring soil temperature.

4.4.1.4. Soil moisture

Soils hold water in the spaces between the soil particles and also as a film on the surfaces of these colloidal aggregations. Soil water retention is greatly influenced by the texture structure and the nature and the volume of pore space. Pore space is very important for air circulation and water conservation in roots. An adequate pore space in the deep layer of the soil of mulberry plantations is a key point for the growth mulberry roots. The pore space in a soil consists of that portion of a given volume of the soil not occupied by solids, either mineral matter or organic matter, being occupied by water and air.

The percent of water in a field sample at any given time is known as the field moisture.

\[
\text{Moisture Percentage} = \frac{\text{Weight of fresh soil} - \text{weight of dry soil}}{\text{Weight of dry soil}}
\]

4.4.1.5 Soil air

The pore space, not filled by the water, is occupied by air. Circulation of air through the soil has a close relation to the fertility of the soil and as the mulberry trees are a deep rooted plant, sufficient amount of air should be supplied to its roots for keeping the growth of trees. Under moist field conditions the non-capillary pore space (macro pores) generally constitutes the air space, the capillary pore space (micro pores) being occupied by water. Ordinarily, the occupation of nearly one-third of the pore space in
the soil by air and two-third of it by water constitutes the most favorable condition of plant growth. The soil air is composed largely of nitrogen and oxygen.

4.4.1.6 Plasticity and cohesion

It enables a moist soil to change shape on the application of force and retain its shape even when the force is withdrawn. Cohesion is the tendency of the particles to stick to one another. Plastic soils are cohesive. Clay soils are plastic and cohesive in which water is logged and are not suitable for mulberry cultivation.

4.4.1.7 Soil water

It is the main component of growing plant. In mulberry around 60 percent of total weight comes from water, and mulberry trees grow consuming incomparable much water to that contained in the body itself. The co-efficient of evaporation is 280-400 in mulberry much less than paddy plants. Thus mulberry tree requires so much water and accordingly the moisture in the soil has a great influence on the growth. Too much water however, hinders the growth. Water serves the following functions in relation to plant life.

- It is an essential part of plant food. It constitutes nearly 90 percent of plant tissue.
- It serves as a solvent and carrier of plant nutrients.
- It maintains cell turgidity and regulates temperature.

Water is held in three forms (i) Hygroscopic water (ii) Capillary water (iii) Gravitational water. The capillary water is the major source of water used by plants.

4.4.1.8 Soil structure

It refers to the arrangement of soil particles, both primary and secondary. It influences aeration, permeability, water holding capacity etc. factors.

4.4.2 Chemical properties

4.4.2.1 Inorganic components

There are 16 elements essential for the plant growth.

a. Elements which come from air and water - carbon, hydrogen and oxygen.
b. Elements which come from soils – Phosphorus, Potassium, Calcium, Sulphur, iron, magnesium, boron, manganese, copper, zinc, molybdenum, chlorine.

c. Elements which come from air and soil- nitrogen.

Nitrogen, phosphorus and potassium are most important elements for the growth of mulberry, soils consists of liquids, solids and gases, and the chemically active fractions of the solid is combined primarily with clay and humus particles and known as the colloidal range. All colloidal clay is known to be crystalline while humus is amorphous.

The total amount of elements contained in the soils depends partly on the nature of the parent material from which they are formed and partly on their age and extent to which soluble products have been leached down.

**4.4.2.2 Humus**

Humus plays a vital role in the productivity and conditioning of soils. It serves as source of food for soil bacteria and fungi which are responsible for converting complex organic materials into simple substances readily used by the plants. The intermediate products of decomposition of fresh organic matter help to improve the physical condition of the soil. The humus or organic soil colloids of soil come from the remains of plants and animals. Chemically humus represent a mixture of decomposed or altered products of carbohydrates, proteins, fats, resins, wax and other similar substances (lignin, tannin, pigments, polyuronides, minerals such as calcium phosphorus, sulphur, iron, magnesium, potassium. These complex compounds are gradually decomposed by soil organisms into simple mineral salts, carbon dioxide, water, organic acids, ammonia, methane and free nitrogen, depending upon the initial composition of the organic matter and an average composition of humus.

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>50</td>
</tr>
<tr>
<td>Oxygen</td>
<td>35</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>5</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>5</td>
</tr>
<tr>
<td>Ash (conta5ining P,K,S and others)</td>
<td>5</td>
</tr>
</tbody>
</table>
Humus available in surface layers of 3 important soils:

<table>
<thead>
<tr>
<th>Soil group</th>
<th>percentage organic carbon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deep black soil</td>
<td>0.34-0.77</td>
</tr>
<tr>
<td>Red and laterite soil</td>
<td>0.68-6.53</td>
</tr>
<tr>
<td>Alluvial soil</td>
<td>0.28-1.10</td>
</tr>
</tbody>
</table>

Humus is amorphous, dark brown to black, soluble in water to a very little extent, can absorb gases as well as water and contains approximately 5 percent nitrogen.

**Functions of humus organic matter:**

1. It is for making the aggregate structure of soils

2. Humic acid of humus absorbs cations and keeps them on the surface of humus particles.

3. Aluminum ions are poisonous to plant roots. Humus absorbs these ions and protects the physiology of roots.

4. Humus absorbs and retains nitrogen, phosphorus, silicate, calcium and other plant nutrients. Thus considered as storehouse of plant nutrients. The decomposed humus releases all the nutrients are available to plant.

5. The refined humic acid or its atrium compound accelerates the plant growth while benzoic acid or vanillin is harmful.

6. Humus releases citrates, oxalates, tartarates, lactates which combine with iron and aluminum more readily than phosphorus thus increases the availability of phosphorus.

**4.4.2.3 Cationic exchange**

It is a reversible process by which cations and anions are exchanged between solid and liquid phases and between solid phases which are in close contact with each other. The cationic exchange capacity is the best index of soil fertility. Ion exchange is the most important of all the processes occurring in the soil. Soil colloids or humus particles are the seats of ion exchange. Cations absorbed on the surface of clay or humus particles are exchanged with those solutions. In general, cationic exchange capacity increases with increase of clay and humus percentage in soils.
4.4.2.4 Soil pH

Mulberry can not grow well in high acidic soils because the roots become inactive in physiological function on account of too much hydrogen ion in the soil. Acidity arises because of continuous application of ammonium sulphate or basic matters such as lime, magnesium or potash flow away by rainfall for long time. The most favorable acidity or pH of soils for mulberry growth is 6.2-6.8. In general, however, a pH from 6.5 -7.0 is considered to be the best range 1 which most nutrients are desirably available to plants. Lime is applied to correct pH.

4.5 Selection of Land

4.5.1 Soil

The soil should be deep, fertile, well drained, clayey loam to loam in texture, friable, porous and with good moisture holding capacity. Saline and alkaline soils are not suitable for mulberry cultivation. Soils with pH 6.2 to 6.8 (slightly acidic) and free with injurious salts are good for mulberry growth. However saline and alkaline soils are corrected with gypsum, sulphur or green manure while acidic soils are improved with lime and green manure.

In India mulberry is grown in variety of soils. In West Bengal in the districts of Maida, Mushirabad and Birbhum mulberry is grown in Indo-Gangetic alluvium soils. These soils are generally grey, light brown to brown in colour. Sandy loam 10 loam in texture with pH between 6.8 to 7.0. These types of soils are generally deficient in nitrogen-humus and occasionally in phosphorus. The soils of Kalimapong, Kurseong of Darjeeling district are acidic with pH ranging from 6.0 - 6.2. In Kamataka, Andhra Pradesh and Tamilnadu the mulberry is grown in red loam, derived from granites and genesis. The characters of red sandy loam is shallow to medium in depth, well drained, underlain with “murrum” and gravel substratum, colour bright red pale brown, poor in water-holding capacity in bases, sandy to sandy loam in texture, alkaline to neutral in reaction and the organic matter content is low. The pH is generally 6.5. These soils are deficient in available phosphorus and contain variable amounts of potash.
4.5.2 Location

It is always desirable to establish the rearing house close to the mulberry garden for quick transport and immediate use of leaves for feeding silkworms. In summer, the mulberry leaves after harvest lose considerable amount of moisture in the rearing house and wither during transport and if the plantation is far away from the rearing house, this will lead to wastage of leaves and loss to farmer.

4.5.3 Topography

In general mulberry is grown best in flat land and also in sloppy land provided proper soil and moisture conservation measures are adopted. Mulberry can be grown in gentle as well as steep slopes. If the slope is below 15° mulberry plantation can be established in rows along the contour, whereas in steeper slopes (15° - 30°) terraces are built for mulberry plantation. It is necessary to improve the fertility level of these soils by supplying periodically compost, farmyard manure and lime. The growth of mulberry is very poor in ill drained soils. Hence the plants have to be earthed up high and proper drainage is provided for economic mulberry leaf yield.

4.5.4 Environmental Factors

The mulberry plant growth and leaf quality are often affected by environmental factors. The neighboring woods, buildings, factories, tobacco, cotton and chilli fields, orchards influence the quality of mulberry leaf. Smoke and liquid effluents from factories are harmful and affect the leaf quality. Nicotine, chilli fields often contaminate the mulberry leaves and poison the
silk worms. Hence great care should be adopted while spraying such chemicals. It is advisable to establish mulberry garden at least about 100m away from these commercial crops in windward direction. In temperate climate as in Kashmir the woods and buildings to the north of mulberry field promote good sprouting of buds and those on the windward side serve as wind-breaks.

4.6 Layout of Plantation

It is a methodical division of the total land selected from mulberry plantation. This process is mainly based on topography, location. The flat land is made into blocks of convenient sizes by leaving some space between the blocks. The space should be little more between the rows of blocks than between the blocks. This block preparation enables the farmer to irrigate easily and to prevent pest and diseases too. It favors us to observe all the plants in the block by moving in space provided. It would be a better approach for fertilizer application also. The cultural operations are also easy. The farmer can estimate the leaf production very easily. The layout of plantation is a scientific approach which would be better for easy cultivation practices.

The sloppy lands are made into terraces of convenient size and height so as to protect soil and moisture. Further, bunding and contour plantation are followed if necessary where the slope is 15-30 percent besides making the land into terraces. The laying out also better for mixed cropping pattern.

4.7 Land Preparation

4.7.1 Soil Sampling

The availability of plant nutrients in the soil in adequate quantities and in readily usable forms is a major factor influencing crop yields. This requires knowledge of the fertility status and physical properties of the soil. Soil testing helps to decide fertilizer dose required for the crop and also for soil amendments to correct the soil. Testing also help to know, which soil is suitable for which crop basing on the nutrient availability? Thus soil testing is essential for every soil and crop.

Soil tests and their interpretations are based on samples analyzed. It is there fore, important that the soil samples should be properly collected and should represent the area. Soil test and their interpretations are as reliable as the samples drawn and hence, must be collected with care.

For routine soil testing, the field is traversed and variations in slope, color, texture and cropping pattern are noted down. The field is divided
into portions according to the variations and separate samples are collected for each of the portions.

4.7.2 Importance of Land Preparation

Mulberry is a deep rooted perennial plant. Its root system goes to a depth of 1-2 meters in the case of a bush. This requires proper ploughing to deep so as to facilitate the development of the root system. Well prepared land with deep digging makes the soil loose and plants find way to establish themselves.

In mulberry cultivation the economic product is the leaf. The water requirement of mulberry is very high thus land should be cultivated deep to make the soil porous. This process is better for rain water to percolate into lower depth and is made available to the plants. Further mulberry cannot tolerate water stagnation. This can be avoided by proper drainage. Terraces are fulfilled in slopping land depending on the gradient. The land preparation involves soil amendments also.

4.7.3 Preparation

One should keep in mind the above detailed factors while preparation of land for cultivation of any crop. It is necessary to prepare the land in proper manner after selection of land for mulberry cultivation. First small bushes, trees, stones are to be removed from the land. The field is to be leveled. Leveling of the land depends upon its topography i.e., flat terrain, sloppy land, terraces. While leveling such areas, the level of the ground water table must also be taken into consideration. If the water level is high, proper drainage must be provided.

Mulberry is an arboreous, deep rooted plant. Thus a thorough preparation of the soil with a deep ploughing or digging is a prerequisite for mulberry, whether it is rain fed or irrigated crop. After cessation of monsoon rains, the land is dug deep with a crow bar in case of small areas. Otherwise ploughing with a heavy mould board plough up to a depth of 30-45 cm is advantageous. The clods are allowed to weather. Then clods are broken, weeds, stones and gravel are removed. The land is then ploughed crosswise to further cut down the furrow slices. Further cris-cross ploughing with country plough the soil is brought to a fine tilt. Deep ploughing helps deep rooting, quick establishment and luxuriant plant growth. The land is to be leveled as flat as possible with the leveler of the soil scrapper. After ascertaining pH, soil is corrected by mixing gypsum or lime. The farm yard
manure is applied at the rate of 10 tones/ha in pits and 20 tones/ha in trenches before planting under rain fed and irrigated cultivations. This manure favors root formation and plant growth. When the fertility level is less, the saplings or seedling do not grow well resulting in loss. Thus establishing of necessary nutrients, growth factors is necessary for any

1) Terraced Mulberry Field

Bench Terrace

The face of the terrace must be protected with Posture process

Contour Terrace

The face of the terrace must be protected with Posture process

Terraces of uniform width are made irrespective of original contour of the land

1) Sloped Mulberry Field

Mulberry bushes are planted along the contour lines

Planting along the direction of the slope

The soil must be ridged along the rows to prevent soil erosion and run-off fertilizers

3) Modified Slope Mulberry

Small trees, bushes are buried in the depression
4.8 Soil erosion and control methods

4.8.1 Normal or geological erosion

In native, the soils are detached and transported at such a slow pace that the soil eroded is almost compensated by the formation of new soil from beneath. This type of erosion is not harmful and natural.

4.8.2 Accelerated soil erosion

When the surface layer of a soil is devoid of natural and other protective cover, it is eroded due to human and animal interferences in large quantity. And new soil formed by nature cannot make up the loss. This erosion is harmful and will rapidly damage the land.

4.8.3 Water erosion

It causes damages by removing soil with its flow. Sometimes it is severe and causes deep cuts which becomes problem for cultivation. The following are the characteristics of soil losses.

4.8.3.1 Sheet erosion

The rain drops churn the top soil which moves away from the field along with runoff muddy water. This erosion removes top soil uniformly as a thin layer. It is the first stage of soil erosion.

4.8.3.2 Rill erosion

The runoff due to sheet erosion initiates to begin channelization resulting in irregular erosion. It causes lot of incisions on the ground resulting in removing and shifting of lot of nutrient soil. Rill erosion results when the water flow speed increases 0.3–0.7 mm/sec. It is the second stage of erosion.

4.8.3.3 Gully erosion

Increased rill erosion increases channelization of runoff. When the water flow to a vast sloping land with large volume and velocity of water induces to cut the soil deeply and increase the width of channel. Such are called gullies to exhibit most spectacular symptoms of erosion. If this is unchecked the cultivation becomes very difficult.

4.8.3.4 Ravines

It is a prolonged process of gully erosion. The gullies are very deep and wide indicating advanced stage of erosion. It is found in deep alluvial soils.
4.8.3.5 Landslides

These occur in mountain slopes when the slope exceeds 20 per cent and width 6m.

4.8.3.6 Stream-bank erosion

Small streams, revolts, tunnels (hill streams) are called stream-bank erosion due to obstruction of water flow. Growth of vegetation in dried stream obstructs the flow causing cutting of bank or change of direction of flow. Generally torrents with flashy flow and swift deposited in the down stream. This results in overflow and stream - bank erosion.

4.8.3.7 Factors influencing erosion

The rainfall, vegetation, soil, man and beast influence erosion. Rainfall influences both the process of detachment and transportation. The intensity, duration, distribution of rainfall increases runoff and soil erosion. Vegetation acts as a cover to prevent erosion. The impact of rain drops is absorbed by vegetation of soil surface, thus no break down of soil, leading to less soil erosion. Soil features have greater impact on soil erosion. Man and beast accelerate erosion by farming and excessive grazing. Cultivation on steep slope, along the slope, wetting and burning of forest lead to heavy erosion.

4.8.3.8 Losses due to erosion

1. Loss of naturally occurring rain water from the field

2. In India soil erosion is 16.3St/ha/year. About 29 per cent of the total eroded soil is lost permanently to the sea and 10 per cent is shifted to reservoirs. This finally results to obstruct plant growth.

3. Erosion involves driving plant nutrients from the top soil leading to economic loss to the farmers. The soluble nutrients are lost along with runoff water and fixed forms with sediment.

4. When the water reaches reservoirs, the flow velocity is reduced and sediment settlers resulting in reducing the depth of the reservoir.

5. Uncontrolled rennet leads to floods causing severe loss to crops, animals and humans.
Plant Nutrient Losses due to soil Erosion

(Kg/ha)

<table>
<thead>
<tr>
<th>Degree of Slope</th>
<th>Organic</th>
<th>Total</th>
<th>P2O5</th>
<th>K2O</th>
<th>CaO</th>
<th>MgO</th>
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<td>0.5%</td>
<td>86.5</td>
<td>5.8</td>
<td>10.7</td>
<td>42.8</td>
<td>53.8</td>
<td>41.4</td>
</tr>
<tr>
<td>1.5%</td>
<td>92.8</td>
<td>6.5</td>
<td>11.1</td>
<td>52.9</td>
<td>59.2</td>
<td>78.5</td>
</tr>
<tr>
<td>3.0%</td>
<td>173.9</td>
<td>19.8</td>
<td>23.5</td>
<td>117.8</td>
<td>23.2</td>
<td>211.8</td>
</tr>
</tbody>
</table>

4.8.3.9 Control Measures

Contour cultivation i.e. contours ploughing, saving and other intercultural operations. This type of practice across the slope act as obstruction to

1) Run off which gives more time for percolation and to reduce soil loss.

2) Conventional tillage includes ploughing twice or thrice followed by harrowing and planking. This kind of tillage alters the soil physical characters and leaves no land unploughed and leaves no residues on the field. Thus conservation tillage is to be adopted as it disturbs the soil to a minimum extent and leaving crop resides on the soil. The soil loss is reduced to 99 per cent.

3) Mulching with plant materials reduce soil loss up to 33 times compared to bare soil and 17 times compared to cropped soil without mulches.

4) Cropping system influences soil erosion. Thus a crop which produces maximum cover is grown to reduce runoff and soil loss.

5) Strip cropping is another process to reduce soil erosion.

6) Chemicals like Polvinyl alcohol at 480 kg/ha are sprayed on soil to increase stability of soil aggregates.

7) Good agronomical practice also plays a vital role to reduce run off. Application of manures, fertilizers, increasing infiltration and soil properties.

8) Mechanical measures such as contour bounding, graded bunching, broad base terrace, bench-terracing, zing-terracing, trenching, vegetative barriers, grassed waterways, gully control are undertaken.
9) Forest waste reduce soil erosion and improve soil nutrients. The vegetation and dried leaves on the floor intercept the rain and reduce the impact of rain water. Re-establishment of vegetation is essential to avoid serious erosion and to maintain ecological balance.

10) Contour trenches are made in non-agricultural and for providing adequate moisture conditions and water levels in order to raise trees and grass species. The size of trench is made depending on slope, rainfall, and soil depth.

11) Plants, trees, grass species are grown on the bank of fields.

12) Grass prevents erosion by interrupting rainfall by its binding power with soil particles. It also improves soil structure. A grass-legume association

13) Is ideal for soil and moisture conservation.

4.8.4 Wind erosion

It is natural phenomena that bare land devoid of vegetation is affected by wind erosion. Wind picks up soil particles, lifts them from surface soil and transports them to a long distance. It is common in arid and semi-arid zones.

4.8.4.1 Factors influencing erosion

1. The climatic factors are wind velocity, rainfall, and temperature. On a loose soil wind velocity is the primary agent compared to sand blasting. Wind velocity of 8-10 m can carry 490 million tones of soil per hectare.

2. Temperature and rainfall influence wind erosion through their effect on soil moisture. The increase in soil moisture decreases wind erosion.

3. Soils with large aggregates and those with surface crust are resistant to erosion. The soil factors influencing erosion are texture, structure, cohesiveness, bulk density, organic matter, moisture content and surface roughness. The most erodible particles are about 0.1 mm or less in diameter.

4. Depletion or destruction of vegetation is the primary cause of wind erosion.

4.8.4.2 Loses due to erosion

1. Loss of fertile surface soil

2. Drifting of sand particles from one place to a fertile good land cover up the soil. This is common along river courses, sea coast and boundaries of desert.
3. The wind driven soil particles and wind velocity cause loss to crops.

4.8.4.3 Control measures

1. Close growing crops are more effective. A long barrier of a several rows of trees across wind direction is useful for soil and moisture conservation.

2. Trees like *Presuppose specigera; Albizzia amare, Tamarindus indica*, are suitable for climatic conditions of the desert.

3. Rough and cloudy field surface with more than 50 per cent of clots, greater than 0.86 mm dia. resist wind erosion

4. Stubble mulching reduces wind velocity and also trap the eroding soil.

5. Wind breaks such as forces, terraces are better physical obstructions to reduce wind velocity.

6. Soil aggregation has to be improved by increasing the organic matter content in the soil.

Wave Erosion

It is result of combined action of wind and water which is common in canal and river banks. It can be prevented by growing grass and trees.

4.9 Soil, moisture conservation

4.9.1 Principles

1. Soil erosion is prevented by controlling the velocity of wind and water.

2. To reduce slope lands by making terraces.

3. Soil is protected from rain water and wind.

4.9.2 Methods of conservation

There are several factors i.e. wind, water, waves which contribute to loss of soil and soil moisture which are vital for plant growth. Besides this loss of nutrients in the surface soil, reduction in storage capacity of reservoirs, to water and soil also occur. This is due to faulty agricultural practice. The soil erosion depends on (i) the type of soil-texture, structure organic content (ii) the degree and unit of slope, (iii) the intensity, duration and distribution of perspiration, (iv) the nature of ground cover including grasses, trees and
agricultural crops. Heavy losses of soil and plant food have occurred due to exhaustive and extensive cultivation.

Soil conservation methods are detailed in different types of erosions of this chapter.

Soil moisture is lost as evaporation from the soil surface and as transpiration from the plant surfaces. The evaporation aspiration losses can be reduced by mulches, anti-transparent, wind breaks and weed control.

**Table 3.2**

Productivity factors of the soil and conservation measures

<table>
<thead>
<tr>
<th>Soil Fertility Factor</th>
<th>Methods of Conserving soil fertility</th>
</tr>
</thead>
</table>
| **Chemical Properties** | 1. Amount of nutrients supplied.  
2. Slow but continuous supply of nutrient. 
3. Reaction, redox potential and buffering capacity of salt concentration 
4. Removal of Toxic substances |
| **Physical Properties** | 1. Water supply capacity, seepage, water drainage and water permeability. 
2. Aeration 
3. Ease in ploughing |
| **Biological Properties** | 1. Promotion of biodegradation (decomposition of organic matter nitrogen, fixation etc.)  
2. Suppression of parasitic activity. |

**Note:** closed circle (*) indicate that the treatment suggested are effective for improving the factors listed against.

**Source:** Nagya Kozo Modai Kenkyu. The asterisks (*) have been added by Kusono
4.9.2.1 Mulching

About 60-75 per cent of the rainfall is lost through evaporation. Mulch is the best method to reduce evaporation. Thus mulch is any material applied on the soil surface to check evaporation and improve soil water. Mulching results in additional benefits like soil conservation, moderation, reduction in temperature, soil salinity, weed control and improvement of soil structure. Mulch improves soil water by reduction of evaporation, runoff and weeds and increases in infiltration. Mulch obstructs the solar radiation reaching the soil and also receives the energy of beating rain drops, and protects break down of soil aggregates. Mulch slows down flow velocity of runoff. It reduces weed germination. White or reflective type of plastic mulches decrease soil temperature, while clear plastic material increases temperature.

A. Mulches

The loose surface soil acts as good mulch for reducing evaporation. And loose soil is called soil or dust mulch. Which can be done by inter-cultivation crop reserves like wheat straw, cotton stalks, mulberry sowings are spread in between the rows as mulches and are called stubble mulch. It protects soil erosion and reduction of evaporation. Plastic materials like polyethylene poly vinyl chloride are also used as mulches. Sub-soiling is a process of breaking hard pans to improve root penetration, aeration and water percolation where the slots are filled with organic matter and keeping them open and functional for a longer period is called vertical mulching.

4.9.2.2 Anti transpirant

The water absorbed by the plant is lost to an extent of 99 per cent during transpiration. Thus anti transpiratns are applied to transpiring plant surface for reducing water loss from the plant. There are four types i.e. stomatal closing type, film forming type, reflecting type, growth retardants, are very effective.

The general activities of anti transpiratns is to reduce photosynthesis, thus the usage is limited to some extent only.

4.9.2.3 Wind breaks

Wind breaks are any structure that obstruct wind velocity.

Besides this rows of trees planted for protection of crops against wind which is called shelter belts. These benefits are seen more clearly in drought years.
4.9.2.4 Weed Control

Weed is an unwanted plant which competes with crop in every aspect that is essential for growth. Thus timely control and elimination of weeds increases availability of soil moisture to crops. It also helps to reduce the rate of transpiration.

Summary

- Rocks are parent materials over which soils developed. There are igneous, sedimentary, metamorphosis rocks.
- Largest share of agriculture land is occupied by alluvial soils. Formed by the deposition of river silt rich in nutrients and this sterile.
- Acidic soils are injurious to plant growth and are neutralized to restore natural characters.
- Accumulation of large amount of organic matter results in peaty and organic soils.
- Dark soils absorbed more heat.
- Mulberry grows best in flat land and also sloppy land.
- Soil testing is very important for every soil and crop.
- Deep digging ensures root development and plant growth.
- The forms of water, wind, wave erosions besides normal or geographical and accelerated soil erosion.
- The principle of soil and soil moisture conservation are prevention of soil erosion.

Short Answer Type Questions

1. Define soil?
2. What types of soil suitable for mulberry?
3. What is soil reclamation?
4. What are acidic soils?
5. Define humus?
6. what is pH of soil? What is the suitable pH for mulberry?
7. Define soil moisture?
8. What is leaching of soil?
9. Why land selection is necessary in mulberry cultivation?
10. What is the importance of soil test?
11. How much deep ploughing is necessary for mulberry cultivation?
12. Define soil erosion?
13. Define mulching?
14. What are the chief control methods of soil erosion?

**Long Answer Type Questions**

1. Define of about Types soil in India?
2. Write about the soils of A.P?
3. Write about soil properties?
4. How do you prepare land for mulberry cultivation?
5. Write about water erosion and control measures?
6. Write about wind erosion and control measures?
7. “Soil and moisture conservation is essential” comment.

**III. Short Notes**


**Numerical Questions**

1. Identify the colour of soil.
2. Collection of soil pH of different types soils.
3. Determine the soil pH of different types of soils.
4. Preparation land.
5. Mulching of soil and uses of mulch materials.
5.1 Introduction
5.2 Sexual Propagation
5.3 Asexual Propagation
5.4 Mulberry Nurseries
5.5 Summary

Learning Objectives

After Completing Chapter you will be able to.

• Explain sexual and Asexual propagation.
• Understand the Grafting, Layering methods of propagation.
• To learn about collection of seeds.
• To learn about Growth regulators.
• Identify stock and scion.
• Understand about trench layering to prepare more than one plant from the only one branch.
5.1 Introduction

Propagation means multiplication of plants. The process and its success mainly depend on the medium in which it is carried. The propagating medium is that which helps the seed or only plant kept in it, resulting in good rooting or germination. Thus the role of medium is vital in propagation of any plant.

Mulberry can be propagated by seeds or vegetative however vegetative method is common, easy and cheap. Further it is advantageous to get desired characters like maintenance of particular characters of the plant, speed in raising large number of saplings, adaptability to a particular habitat, resistance to pests and diseases and produce viable seeds. Due to bi parental origin a seed cannot produce a true type of plant. Different vegetative propagation methods are followed in different countries depending on the environmental conditions and soil nature. In India mulberry is propagated through common and popular method-cuttings in multi voltine areas like Karnataka and West Bengal. In other parts root grafting is followed where exotic varieties cannot be raised by cuttings.
Nursery is a process of plant propagation in which seeding or cuttings are grown in a small area. The nurseries are good for any crop. It is most advantageous process in cultivation. More number of plants is grown in a small area. Incidence of disease, pests is nil and cost is also less. After transplantation, if there are any gaps in the field once again plants can be planted. Therefore, it is essential for a farmer to know about the nurseries.

### 5.2 Sexual Propagation

In this mulberry is propagated through seeds. This method is very easy and cheap. Sexual propagation is mainly to bring about a varied population for the purpose of selection and hybridization. The seeds are used to obtain stock material for grafting. It is also suitable for large-scale multiplication. But long gestation period to provide learner for silkworm rearing and desirable traits of improved cultivars cannot be perpetuated.

#### 5.2.1 Seed Collection

Seeds are collected from ripe fruits in March-April in tropical region and May-June in temperate region. There is no dormancy in mulberry seeds. They lose viability with the passage of time. If preserved beyond three months, Seeds should be stored in a sealed air-tight container kept in a cool place. However freshly harvested seeds have highest germination ability. Squeeze the fruits to separate pulp from the seeds. The floating seeds are removed along with water and heavier seeds settled down are collected carefully and dried on a blotting paper. The mulberry seeds are small and about 300,000 seeds are required to fill one liter volume.

#### 5.2.2 Nursery plots

Plants grown from a seed is called seedling are grown in a nursery. The nursery plot is selected preferably under shade in the farm. The soil is thoroughly dug to prepare to a fine tilt. The sowing medium is prepared by mixing equal quantities of red earth, sand and FYM. Nursery beds of 0.9, size are prepared with a provision to protect young seedling form excessive light and temperature.

#### 5.2.3 Sowing of seeds

The mulberry seeds are soaked for a day in water to soften the hard testa for easy and successful germination. Seeds are broadcast or sown in holes in nursery beds. Sowing is carried with the help of rope so as to make the holes in a line. The seeds should not sow deeper than 2.5 cm to avoid delay in germination or total failure. A distance of 2-3 cm between rows
and 1 cm between seeds is advisable for better germination. After saving
holes are covered with soft soil and water is applied gently.

### 5.2.4 Seed germination

The environmental conditions i.e., temperature, light play vital role in
seed germination. Therefore seed beds are covered with dams made of
bamboo strips or palm or coconut leave to protect from severe sun. The
protective mats are placed one foot above the nursery beds on pegs fixed
around them. In our conditions seeds germinate after ten days. Low
temperature and colored light delays seed germination.

![Fig 5.1 Stages of Seed Germination](image)

**Propagation methods of mulberry**

#### 5.2.5 Seedlings

Seedlings require proper nutrition for uniform growth. Thus the
seedlings of 3.5-5cm height are picked from dense areas and planted in thin
areas. During cool hours of the day and on cloudy days direct sunlight is
allowed to fall on the seedlings to enhance plant growth. After three months
of age seedlings are transplanted with a distance of 22 cm between the
plants. There can be either used for grafting (stock plant) or allowed to
grow for two years to raise tree plantations.
5.3 Asexual propagation

It is the most popular method adopted in moriculture. It favors to utilize vegetative parts of a plant to grown them into a individual plant. This propagation method is very easy though it is technical. There are different methods to utilize branches, buds, roots in this propagation.

5.3.1 Cuttings

Most of the tropical varieties of mulberry can be easily propagated on large scale through cuttings. It is easiest, common and popular method in India. But this method is restricted to acclimatized local varieties. The plants are selected on the basis of nutritious leaf, high yield, quick growth resistance to diseases and insect pests and drought resistant varieties. This propagation is easy, cheap and quick. Mulberry being a cross pollinated plant, the improved traits of the cultivar are retained by this method. Shoots of proper maturity, 8-10 months old, with active and well developed buds are selected. Over mature and tender tips are rejected. The branch must have 10-12 mm in diameter. The cutting of, 18-20cm long with three or four active buds are prepared with a sharp implement so that neither the bark nor the wood portion is damaged. The ends must be slant (45 deg), without damaging the bark or splitting base.

Cutting size     18 -20 cm long
                 3-4 buds                -    Irrigated farm
Cutting size     20-24 cm. long
                 5-6 buds               -    Rain fed farm

These cuttings can be planted in the field directly or in nursery beds. In case of nursery, care must be taken to avoid drying. After two or three months, sprouted cuttings are transplanted into the field.

5.3.1.1 Development of roots

The roots develop from the basal end of the cuttings. The roots develop endogenously. The root initials developed initially finally produce root primordium so as to form root tip, which grows outward and emerges at right angles to the stem. Simultaneously callus tissue develops at the basal end of the cutting and becomes stem of the future plant.

Nursery is the better choice for growing cuttings which are later transplanted into the fields. This method avoids gaps in the field which is
common in direct plantations. The cuttings can also be well preserved when the field is not ready for plantation. They are bundled and stored in deep pits (one foot depth). Or in sand, then are wet by sprinkling water with regular intervals. The latent buds are activated and callus develops. After preparing the field they are uprooted and planted in the field.

5.3.1.2 Growth regulators

Root hormones are used to certain mulberry varieties which don’t produce roots from cuttings. This is followed in temperate regions. The rooting capacity is considerably improved by growth regulators. Plant growth regulators are complex organic compounds other than nutrients. Which when applied in a minute quantity, are able to promote or inhibit growth. They are Indole 3-acetic acid (IAA), Indole 3-butyric acid (IBA), Naphthalene acetic acid (NAA), 2,4-dichlorophenoxy acetic (2, 4-D), rootone, senadix. The chemicals act like auxins and promote root development. These chemicals are applied in the following methods.

a. Quick dip method
b. Prolong dips method
c. Powder method
d. Paste method

These chemicals increase cell division rate which is not possible in few plants due to the non-viability of these substances. However duration of treatment has a considerable effect on the root formation in lower and higher concentrations.

5.3.2 Grafting method

It is a technical joining of a branch of one plant into a rooted plant in such a way that they unit with an organic union formed in between them, and finally grow as one plant. It is practiced where the plant cannot be propagated through cutting, because of poor rooting.

**SCION** - The plant part of the graft combination which is to become the upper portion of the shoot system of the new plant.

**STOCK** - The lower plant part with root base, which supports and supplies nutrients to scion, to grow as new plant.

Thus the stock must be a local, handy variety and scion is selected from the desired or indigenous variety. The total strength of the future plant variety depends on the stock as it alone influences the growth. Thus the stock should be in a more advanced stage of growth than the scion. This method facilitates to get desirable qualities which cannot be propagated by other means.
5.3.2.1 Basic principles of grafting

- Compatibility of stock and scion
- Maximum cambial contact between scion and stock
- Local adaptability of stock and superiority of scion.

5.3.2.2 Selection of plants

The stock should be from 1-2 years old seedling. It should be healthy and highly resistant to diseases and pests with rich root growth. Stock should be slightly bigger or same size as that of scion. Scions are chosen from one year old plants. Only middle parts of shoots are used leaving the top and base regions. The leaves from these plants should not have been plucked during the previous year. Further it should have narrow and compact pith.

5.3.2.3 Formation of graft union

- Establishment of contact of large area of cambial region of both the stock and scion.
- Production and interlocking of parenchyma cells (callus tissue) of both the stock and scion.
- Differentiation of new cambium across the callus bridge.
- Formation of xylem and phloem from the new vascular cambium in the callus bridge.

The insertion of scion into the stock establishes organic union by the formation of secondary vascular tissue. The cell division increases to form callus tissue during proper temperature i.e., 20-40°C. Further it is necessary to maintain high humidity.

Depending upon the type of material used, its nature age and portion of the stock, grafts are of the following types: wedge and crown grafting, whip, root, bud grafting.

5.3.2.4 Shoot grafting

The scion is inserted into the stock stem is called shoot or stem grafting. It is of many types.

Wedge grafting is a method to remove the old plant. The plant is pruned at a convenient height and a ‘V’ shaped incision in made at the cut surface. The basal region of scions cut obliquely to fit in the incision made on the stock plant. The scion is inserted into the stock and grafting wax/clay is
applied. Grafting wax is prepared with a mixture of tallow part, bee wax one part and resin four parts melted together and baked with small dough under water.

B. Bud Breaking of Winter Bud

Fig. 5.2 Cutting and Its Development
Shoot Grafting

Fig. 5.3 Shoot Grafting

Crown Grafting

Fig. 5.4 Crown Grafting
Wedge Grafting

![Image of wedge grafting]

a. Stock   b. Scion   c. Graft Union

Fig. 5.5 Wedge Grafting

Whip Grafting

![Image of whip grafting]

a. Stock   b. Scion   c. Graft Union

Fig. 5.6 Wedge Grafting

The grafting clay is prepared with two parts of clay, one part cow dung and chopped hay mixed with water.
Crown grafting is a method where more than one scion is inserted into the stock to get a bushy plant.

In whip grafting a slope cut is given to a length of 3.5 to cm to the stock of 1.2 to 2.5 cm thick. The scion of same size is cut in similar process so as to fit in the stock, and inserted into the stock and tied firmly with soft fibre. The site of join is sealed with grafting wax or clay.

5.3.2.5 Root grafting

The root is used as a stock instead of shoot. Roots of 0.6 to 2.5 cm thick are selected from a local, one year old seedling and cut into pieces of 5 to 7.5 cm long. The top end is cut obliquely. The scion of 8 to 10 cm long, little thinner than stock and with two or three buds is prepared. The basal end should be oblique with the end tapering to provide a stiff tongue. The scion is inserted at the pointed end of the stock between wood and bark. While inserting the bark at the pointed end of the scion is removed. The cut ends of both stock and scion should be in the same direction thus cambial layers are in close proximity to each other. The exposed cut is covered with a thin layer of wax and no bandage is required. These grafts are planted in a well prepared nursery bed so that 1 or 2 buds of the scion are above the soil. Water is applied regularly. The developing plant possesses scion characters.
This method is simple, highly efficient, easy, quick economical and good for root development. The percentage of success is more and an individual can prepare 800-1000 grafts in eight hours. A two year old seedling given five to six stocks and all can be used as grafts to get five to six plants, which minimizes cost of labour. But it is necessary to remove the latent buds completely.

![Diagram of T. Budding](image1)


Fig. 5.8 T. Budding

![Diagram of Patch Budding](image2)

A. Bud stick, B. Bud and Shield, C. T.cut in stock, D. Inserted Bud E. Completed Bud Graft tied with rubber band

A. Cut around Bud. B. Cut made to receive Bud. C. Bud ready for insertion. D. Bud inserted. E. Shoot growth from bud about a year later

Fig. 5.9 Patch Budding

In the “in situ” grafting method, the scion is grafted on to the root of existing plant, without disturbing the root from its original place. Though a more vigorous plant is obtained but only one graft is developed from a seedling. Further, it is necessary to take care in cutting the root below the transitional zone, to prevent sprouting from the region of the local stock plant. The method of doing is same as root grafting.
5.3.2.6 Bud grafting or Budding

It is a better method when the scion material is scarce. In this grafting only one vegetative bud with a piece of bark is used as scion material, thus called as bud grafting, which has all the advantages of grafting. It is much practiced in temperate regions of the country. The removed bud piece contains periderm, cortex and phloem which are laid against the exposed xylem of the stock. The inner surface of bud piece and exposed surface of stock form callus strands, which join to form Callus Bridge finally resulting in formation of secondary xylem and phloem. These vascular strands are connected to the original xylem and phloem.

This method minimizes the use of scions and reduces disease transmission. But it takes a long time of two years for a plant to grow.

There are various types of budding depending upon the types of the bud. They are ‘T’ budding, inverted ‘T’ budding, patch budding, flute budding, chip budding and ring budding.

‘T’ budding refers to the cut given on the stock in the shape of the letter ‘T’. It is also called as shield budding as the bud prepared will appear like a shield. A cut is given on the stock (1-2 cm diameter) at inter nodal region (25 cm height from ground level). A vertical cut is given to a length at about 1-2 cm, and then cut horizontally at the top of the vertical cut which appears like ‘T’. Then slowly bark is removed to insert the bud. After selecting the required bud make a slanting cut below the bud, and lift it upward to about 2.5 cm length above the bud. Gently remove the bud and insert in ‘T-cut of stock and wrap the union tightly with a polythene strip exposing only the bud.

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A. Ground Layering

B. Development of Roots

Fig. 5.10 Simple Layering
The inverted ‘T’ budding is exactly opposite to that of ‘T’ budding. In ‘T’ budding there is possibility of water drops entering the cut made on the stock and may lead to damage the bud inside. In inverted ‘T’ method water entry is prevented.

In **patch budding**, a patch of bark with an active bud is removed from the bark of scion. A patch of bark of similar size is carefully removed from the stock in the inter nodal region. Then patch with bud of the scion is inserted on to the stock and properly bandaged with a soft fiber and covered with grafting wax or clay.

**Flute budding** is a modified method of patch budding. The bark (Stock) of the plant is cut to a length of 2 ½ to 3 ¼ cm round and removed as a sheath at the inter nodal region. The removed bark looks like the letter ‘C’. The bud of the scion is also removed in similar manner and inserted in the stock and bandaged properly after applying grafting wax.

Precautions – The size of the scion and cut portion of the stock must be equal. While removing the bud, no woody portion should stick to the bark. It is necessary to remove all buds below and above the budded portion only. There should not be any empty space between the scion and the cut portion on the stock. The stock should not be damaged. The cut or site of insertion should be bandaged properly to prevent entry of water and air. It is necessary to inhibit sprouting of other buds on the stock.

**5.3.3 Layering**

It is a process of development of roots on a stem while it is still attached to the parent plant. The rooted stem is detached to grow as a new plant and called as a layer. Root formation on the stem during layering is stimulated by various treatments which cause the interruption in the downward
translocation of organic material (carbohydrates, auxins and other growth regulators) from the leaves and shoot tips. These materials accumulate near the point of treatment and cause the formation of callus. Then callus develop roots.

This method is simple, safe and cheap than any other method. It favors to get a large sized plant in a short time. There is no chance of root drying. The disadvantages are time consuming, expensive and not suitable for large scale production. After root development the branch is separated from mother plant and used as sapling. This method helps to fill up gaps in the field. There are different types.

**Fig. 5.12 Air Layering**

**Simple Layering**

In simple layering a lower branch bent and bark is removed to a length of 2.5 to 3 cm in middle region of the branch. The branch is then bent slowly to the ground and treated part is covered with soil leaving the terminal end free and exposed. It is protected from dislocation, the out and inside the soil with the help of a wooden pet or a fork. Root initiation takes place at the bent and buried end, within two or four months, which is then cut off from mother plant and transplanted to grow individually.

**Trench Layering**

In trench layering a branch of growing plant is bent and covered with soil and manure leaving the tip exposed. The roots develop from the buds
along with the stem grow upwards to the soil and roots on opposite direction. This process is better to get number of layers from a single branch.

**Air Layering**

Air layering is a propagation to induce roots on an aerial shoot. The method involves making a girdle at a point 20-40 cm from the tip of the shoot just below the node by removing a strip of bark 2-5 cm wide. Exposed bark is scraped to remove the traces of phloem or cambium. The griddle is covered with propagating medium and tied with a polythene strip not to allow water or insect in to cut portion. After two or three months polythene cover is removed and rooted stem is cut for plantation.

**5.4 Mulberry Nurseries**

The scale of mulberry plantations and their utilization is determined according to the plan of silk worm rearing. In order to harvest a plentiful good-quality leaves, one must requires adopting cultivation practices. This generally depends on the number of plants available in the field, nutrients available in the soil, irrigation facility, drainage etc., besides aerial environmental factors. Thus it is necessary for a farmer to see that all the plant in the field grow properly since they are planted. There should not be any gaps in the field, which causes uneven distribution of nutrients among the plants reflecting on the quality of leaf. Establishment of optimum plant population is essential to get maximum yield. However the yield per unit areas is increased due to efficient utilization of growth factors. Besides all these factors plant survival factors are essential especially for rooting. This problem arises when mulberry cuttings are planted directly in the field, which can be solved by adopting nurseries.

**5.4.1 Nursery bed preparation**

Nursery facilitates the plant or seed for luxuriant growth by supplying essential nutrients, water, soil. Nursery has to be established four months before mulberry cultivation. It is better for seedlings. Generally cultivation starts with onset of monsoons. Instead of planting mulberry cuttings directly in the field, it is better to plant seedlings that are grown in nursery. Because these seedlings are grown in healthy conditions and thrive better after transplantation.

First a suitable place in the farm is to be selected for nursery. This is ploughed deep with tractor and left for 10-15 days. Later ploughed in criss-cross to make the soil to a fine tilt. The plot is divided into 8 x 10 yards nursery beds with 8-10 inches bund. Irrigation provision is made with 30-
45 cm size canal. For each bed add 20kg of cow dung and mix well. If the nursery soil is clay a sufficient quantity of sand is added or the bed with more sand is added with tank silt. Such nursery beds are 7-8 inches height on the ground.

5.4.1.1 Planting & Maintenance

The planting distance of 15cm between rows and 10 cm between plant cutting is followed. Plant the cuttings at an angle with at least one bud at the top. Cuttings must be planted the right way up. The cuttings are given optimum moisture by supplying necessary water. Depending on the water requirements the beds are irrigated once in 4-6 days. The cuttings once planted in the nursery are fostered for several months until they are transplanted to mulberry plantations. The suitable time for planting cuttings is the beginning of rainy reason. If the time of planting cuttings is delayed until the later half of the rainy season, the growth of the mulberry saplings is insufficient to stand the severe climate of the next dry season.

The nursery beds with sufficient sand and nutrients favor the growth of the cuttings. The root system develops well. Weeding is carried on once after 30-40 days and again after 50 days. Inter cultivation process is conducted with utmost care not to damage the roots.

The cuttings sprout within 5-6 days. Nursery saplings are supplied with fertilizer after 5-6 weeks. For which complex fertilizer (25:25:25) NPK, one kg/ha is advisable. Nursery is screened from the sun with bamboo mat to prevent cuttings from desiccation. It also provides the needed-soil-temperature and air-humidity.
5.4.2 **Planting material**

The mulberry cuttings are obtained from lower part of thick shoot which resulting vigorous rooting. The shoots are prepared from a selected variety. The shoots of 6-8 months old, dark brown color, pencil thickness are chosen for cutting preparation. Cuttings of 15-18 cm. long with 3-4 buds are required for irrigated mulberry. Rain fed mulberry requires 22-24 cm long with 5-6 buds cuttings. The ends must be 45° angles, without bark pealing and split.

![Fig. 5.14 Mulberry Cuttings in Nursery](image)

5.4.3 **SPACING**

This parameter is essential for any type of crop. Proper spacing between the rows and between the plants enables equal distribution soils nutrients. Thick population induces competition for nutrients, soil moisture, minerals etc., among the plants. Uneven or irregular spacing results in irregular growth and poor crop results. Since mulberry is grown for quality, succulent, palatable leaf needs to be given proper spacing while planting. Further mulberry being a deep rooted perennial plant and grows into either tree or can be grown as bush. Thus in nursery plantation the spacing of 15cm between the rows and 10 cm between cuttings, is suitable. This spacing is essential in view of growing plant till it attains 5-6 weeks age and becomes ready for transplantation. The survival rate and sprouting depends on the spacing by which nutrient supply is enhanced.

5.4.4 **TRANSPLANTATION**

It is a cultivation practice in which saplings or seedlings are uprooted from nursery and planted in the field. Saplings grow to a height of 3-4 feet within four months. Nursery is supplied with lot of water 2-3 days before uprooting. It is to loosen the soil and not to cause any damage to root
system while uprooted. Saplings are uprooted using pick axe or sickle. Then these are bundled carefully and wrapped in gunny bag for transporting. These saplings or seedlings are planted in the field according to the system of cultivation i.e., row system and pit system using a long rope to provide them good spacing between the rows and between the plants.

**Summary**

- Mulberry can be propagated sexually and asexually.
- Sexual propagation by seed. Asexual propagation by vegetation part of the plant.
- Growth regulators promote root and stem growth.
- Technique to join two plants is grafting.
- Any plant part or tissue can be produced into a new plant in tissue and organ culture. Nutrient medium is basic need for tissue culture.

**Short Answer Type Questions**

1. Mention propagation methods?
2. Differentiate seedling and sapling?
3. What are the characters of Good Cutting?
4. What is Grafting?
5. What is layering?
6. What is trench layering?
7. What is Gooting (or) Air layering?
8. What is use of growth regulators in propagation?
9. Mention hormone application methods?
10. What are the qualities of good medium?

**Long Answer Type Questions**

1. Explain about sexual propagation of Mulberry.
2. Write about Root grafting.
3. Explain about shoot grafting.
4. Describe Bud grafting.
5. Explain about layering methods of mulberry.

6. Write short notes on:
   a) Cutting
   b) Gootin
   c) Patch budding
   d) Seedling
   e) Growth regulators
   f) Qualities of good medium.

**Numerical Questions**

1. Preparation of cuttings.

2. Preparation of Nurseries

3. Collection of Mulberry seeds.

4. Preparation of stock and scion

5. Grafting methods are adopted in Mulberry garden (Root, Shoot, Bud grafting methods).
UNIT 6

Cultivation and Cultural Practices

structure

6.1 Introduction
6.2 Garden implements and Uses
6.3 Selection of Mulberry Variety
6.4 Mixed Cropping is more useful for a small farmer
6.5 Cultivation Methods
6.6 Weeds and Inter-Cultivation
6.7 Pruning and Training
6.8 Irrigation
6.9 Water requirement for Mulberry

Learning Objective

After completing this chapter, you will be able to:

• Understanding what are the equipments required and how to use that equipments.
• To learn about cultivation methods.
- Identify the weeds and control the weeds.
- Learn types of pruning and training methods.
- Understand the plantation and spacing of plant in irrigated (Row system) and Rainfed (pit system) methods.
- Understand water shed management and different methods in irrigation.

### 6.1 Introduction

Mulberry silkworm is monophagous, feeds on mulberry leaves alone hence cultivation of mulberry is the most important activity for rearing of silkworms and production of cocoons.

However, it is important to note that, before planning for silkworm rearing one must be able to assess the capacity of mulberry garden and the quantity of leaf available to procure the DFLs (Disease Free Layings) for rearing.

Weeds are the unwanted and undesirable plants that interfere with the utilization of land and water resources and they adversely affect the main crop. Weeds can also be referred to as the plants out of place.

Weeds include all types of undesirable plants-grasses, aquatic plants
Weeds are of great menace in the field as they compete with the main crops for fertilizer, soil moisture, and nutrients. The intensity of weed attack varies at field level. It depends upon the (a) type of weed species, (b) duration of weed infestation (c) severity of weed infestation and (d) climatic conditions which favors weed infestation.

The weeds reduce the annual crop production for 10-25%. This variation depends upon the degree of weed attack and weed control measures.

Undesirable vegetation also flourishes in aquatic systems, forestry, and non-cropped areas such as industrial areas, roadsides, water tanks, railway lines, water ways etc., thus plants of many types become weeds in particular situations.

Weeds compete with main crops for nutrients, soil moisture, light, aeration, space, fertilizers etc. Crop yields drastically come down if the weeds growth is not controlled. Generally, it is estimated that one kilogram of weed growth in the field corresponds to reduce one kilogram of crop growth. Even during the drought conditions, the weeds survive better than the desired plants. Weeds remove the nutrient contents and soil moisture enormously than the field crop. Therefore, inter cultivation at regular intervals is more important not only in mulberry crop but in all types of crops.

Methodical cutting of certain mulberry branches periodically is called pruning in other terms pruning in mulberry may be defined as the methodical removal of certain branches of the plants so as to give the plant (i) convenient shape and size (ii) to increase the leaf yield and (iii) improve the leaf quality.

Trimming or shaping of plants into a convenient for is necessary for easy harvest and inter cultivation (i.e., ploughing in the middle rows).

### 6.2 Garden implements and uses

The important implements that are commonly used in mulberry cultivation are as follows. These are grouped into seven types. They are digging, garden, transplanting, propagating, pruning, leveling, irrigation implements.

#### 6.2.1 Digging Implements

These are used for light digging, canal preparation etc.
**Hand Kuddali:** It is made up of cast iron with a wooden handle. Used for digging the soil upto 8”-10” depth. It can also be used for intercultural operations (fig. 6.1).

**Crow bar:** It is a 6' long iron rod with 2” diameter with one sharp, flat end used for deep digging, making pits in hard soil and also to move stones (fig. 6.1).

**Pick Axe:** This is made up of cast iron measuring 2” with one sharp end and other end being flat and sharp. There is a round hole for fixing wooden handle. It is used for deep digging, opening of trenches, digging pits, loosening of soil, uprooting the weeds (fig. 6.1).

### 6.2.2 Garden Implements

These are used for only gardening purpose especially to attend each and every plant during inter cultivation.

**Digging fork:** It has four long, pointed prongs measuring 12” long with a wooden handle. It is used for leveling, digging and also useful in hill areas. It is a better implement for loosening the moist soil and mixing manures in pits (fig. 6.2).
**Hand Cultivator:** It is to loosen the soil during inter cultivation and uprooting grass and other weeds. It is a iron implement with 5 prongs which are curved, pointed at the free end. All these prongs are held tightly to a handle (fig. 6.2).

**Hoe & Rake:** It is a combination of hoe and rake with a hole in the middle for filling the handle. The sharp blade is 14 cm. long while prong part is 15 cm. long. It has four stout (1½” dia) pointed prongs. It is used for light digging especially during inter cultivation to loosen the moist soil and also for weeding. (fig. 6.2).

**Garden fork:** It is of cast of four long or aluminum make with form pointed prongs projecting from a handle. It is for inter cultivation, leveling (fig. 6.2).
Weeding Sickle
Pruning Saw
Secateur
Garden Shear
Kolugudli
Pick Axe
Digging Fork
Crow Bar
Transplanting Trowel
Hand Fork
Water Can
Water Pop
Iron Pan
Iron Pan
6.2.3 Transplanting Implements

**Spade:** It has a broad blade with one free end and other end is fixed to a handle. It is used for uprooting the saplings, seedling from nursery, mixing the manure, for light digging, loosening soil, to prepare irrigation channel, making ridges and furrows (fig. 6.2).

**Shovel:** It has a long wooden handle fixed to a blade with tapering or flat end, measuring 3’ long. It is to carry or lift the soil. It can also be used for transplantation process.

**Dibbler:** It is a fine sharp implement is used to make holes at the time of transplanting of seedlings, saplings. It can also be used for pit system plantations (fig. 6.2).

**Transplanting trowel:** These are garden and transplanting trowels differ just in size. Both can be used for mulberry garden generally made of aluminium. It has a handle and cone shaped spoon used to lift the sapling or seedling along with some soil without disturbing the roots. (fig. 6.2).

6.2.4 Propagation Implements

The vegetative preparation of mulberry is very popular, and can be propagated by all methods.
Bill hook: It is a thick long blade measuring 12" with a 6" handle, made up of completely iron. There is single and double edge bill hook. The edge is very sharp to cut big mulberry branches. It is used specially for preparation of cuttings and can also be used for shoot rearing. Because the cuttings are made with a technique for which this implement is better (fig. 6.3).

Budding knife: It has a single blade 17 cm. long can be folded into a socket of 8 cm. long. The other end of socket has 2.5 cm size budder to lift the bud after making necessary incision (fig. 6.3).

Grafting knife: It is similar to budding knife but lacking budder. It is used for grafting both stem and root to cut stalk and scion plant material (fig. 6.2).

Budding cum grafting knife: It is a combination of budding and grafting knives measuring 5.5 cm, 5 cm long and can be folded into only one socket. It is used for budding and grafting purposes (fig. 6.3).

6.2.5 Pruning Implements

It is one of the important cultivation practices aimed to increase the number of branches so as to improve the leaf yield.

Pruning sickle: It is like a common sickle with 5" long wooden handle. The inner edge is like saw blade. It is used for cutting small branches (fig. 6.3).

Pruning saw: This saw is of 12" or 14" long with a proper wooden handle (5"). It is used to cut thicker branches while pruning (fig. 6.3).

Pruning knife: It has 4" folding blade or fixed blade with one sharp end fixed to a wooden handle. It is used for cutting thinner branches.

Secateur: It has two stout, curved jaws which are clutched with a powerful spring. It is 10" long implement with two separate handles for two jaws. The spring improves its functioning. It is used for cutting thinner branches (fig. 6.3).

Garden shear: It has two metal blades with plain edges with notch & wooden handle. The two blades move over each other. It is of 8", 10", 18" long sizes. These big scissors usually used for clipping and pruning of plants (fig. 6.3).
Tree pruner: It has very sharp stout knife can be made to move with spring action attached to handle. It is too strong to cut thick shoots in a tree of a height of 5’ and above.

6.2.6 Other Implements

Water can with rose: It is made up of 24 gauge G.I. sheet. The can is 24” diameter with 12” height with 6” height. Along (15”) pipe with 4” dia rose is fitted to the bottom of the can. It is used for watering nursery beds, seed beds and potted plants to avoid washing away (soil erosion) of the soil and damage to young seedlings.

Watering pot: It is used for irrigation of individual plants.

Iron pan: It is made of black sheet with 16” radius weighing 1300 gms. approximately duly bedded on top. It is used for transporting sand, soil, FYM etc.

Plough: It is used for ploughing the land for mulberry cultivation.

Wheel barrow: It is used for transporting manure, fertilizer, seedlings, saplings. It rests on two legs and moves with a gentle push.

6.3 Selection of Mulberry Variety

Selection of improved mulberry variety for a given area is an important factor. There are many varieties available in field level, of which there are specific varieties which will be suitable for different areas. They variety of mulberry should be selected on the basis of agro-climatic conditions, soil condition and water availability.

6.3.1 Under irrigated condition

There was only local variety mulberry cultivated both under rain fed and irrigated condition particularly in south India.

A new M₃ variety was introduced, which gives higher yields than local mulberry variety. Central Sericulture Research and Training Institute, Mysore (CSR & TI) has evolved high yielding mulberry varieties suited for irrigated condition viz., S₅₁, S₆₃, V₁ etc.

Performance of Mulberry Varieties
(under field trails)

<table>
<thead>
<tr>
<th>5 yrs. Mean yield under labcondition</th>
<th>5 yrs. Mean Yield under labcondition</th>
</tr>
</thead>
</table>

...
<table>
<thead>
<tr>
<th>Variety</th>
<th>Kg/ha/annum</th>
<th>kg/ha/annum</th>
</tr>
</thead>
<tbody>
<tr>
<td>M₅</td>
<td>34396</td>
<td>22673</td>
</tr>
<tr>
<td>S₃₆</td>
<td>42651</td>
<td>24964</td>
</tr>
<tr>
<td>S₅₄</td>
<td>45098</td>
<td>25888</td>
</tr>
<tr>
<td>V₁</td>
<td>55000</td>
<td>45000</td>
</tr>
</tbody>
</table>

From the above field trial it can be observed that the performance of S₅₄ and V₁ are found good both at farmer and field level as well as under laboratory condition.

6.3.2 Rain fed conditions

Performance

<table>
<thead>
<tr>
<th>Aug. yield in farmer’s condition kg/ha/annum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variety</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>S₃₄</td>
</tr>
<tr>
<td>S₁₄</td>
</tr>
<tr>
<td>S₁₃</td>
</tr>
<tr>
<td>K₂</td>
</tr>
<tr>
<td>Local</td>
</tr>
</tbody>
</table>

The CSR & TI, Mysore has evolved improved varieties viz, S 13’ S 14 and S34 etc. which gave good yield over the local variety and the quality of leaf is found to be superior.

Kanva-2 (35.0 MT/ha/yr/under irrigation) a selected mulberry variety was an accident was the traditional local variety (25.0 MT /ha/yr/under irrigation). However, the new variety which are evolved recently viz., S₄₁', S₃₆', S₅₄', S₁₃₅', S₂₃', S₁₃', VI and S₁₄' were to make field trials of which S₃₆ and S₅₄ have been already released in the field. The average yields of these two varieties are found to be 50-55 MT/ha/yr under irrigation.

The new varieties for rain fed area are S 13, S 14, S34, S21 and S28 which are high yielding under rain fed condition.
### A. Schedule Operations for rainfed mulberry (1st Year)

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Operations</th>
<th>Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Digging (crowbar/disc plough)</td>
<td>November/December</td>
</tr>
<tr>
<td>2.</td>
<td>First ploughing</td>
<td>January/February</td>
</tr>
<tr>
<td>3.</td>
<td>Second ploughing (also levelling to give a fine tith)</td>
<td>March/April</td>
</tr>
<tr>
<td>4.</td>
<td>Pit preparation</td>
<td>April</td>
</tr>
<tr>
<td>5.</td>
<td>Planting</td>
<td>May</td>
</tr>
<tr>
<td>6.</td>
<td>Hand weeding (first)</td>
<td>June</td>
</tr>
<tr>
<td>7.</td>
<td>Hand weeding (Second)</td>
<td>July</td>
</tr>
<tr>
<td>8.</td>
<td>Hand weeding (third)</td>
<td>August</td>
</tr>
<tr>
<td>9.</td>
<td>Hand Weeding (fourth)</td>
<td>September</td>
</tr>
<tr>
<td>10.</td>
<td>Ploughing (first)</td>
<td>October/November</td>
</tr>
<tr>
<td>11.</td>
<td>Harvest (first)</td>
<td>December</td>
</tr>
<tr>
<td>12.</td>
<td>Ploughing (second)</td>
<td>December</td>
</tr>
<tr>
<td>13.</td>
<td>Harrowing (first)</td>
<td>January/February</td>
</tr>
<tr>
<td>14.</td>
<td>Harrowing (second)</td>
<td>February/March</td>
</tr>
<tr>
<td>15.</td>
<td>Harvest (second)</td>
<td>April</td>
</tr>
<tr>
<td>16.</td>
<td>Pruning</td>
<td>May - June</td>
</tr>
</tbody>
</table>

### B. Schedule of Operations for rainfed mulberry (2nd Year onwards)

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Operations</th>
<th>Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Annual bottom pruning</td>
<td>With commencement of south - west monsoon rains (early June)</td>
</tr>
<tr>
<td>2.</td>
<td>First weeding and inter-cultivation</td>
<td>Within a week after pruning (mid June)</td>
</tr>
<tr>
<td>3.</td>
<td>Application of bulk organic manure @ 10 tonnes/ha. and incorporation of the same</td>
<td>Within a month of pruning (early June)</td>
</tr>
<tr>
<td>4.</td>
<td>First picking of leaves</td>
<td>About 2½ months after pruning (mid August)</td>
</tr>
<tr>
<td>5.</td>
<td>Application of first dose of fertiliser @ 50N, 50P, 50K per ha.</td>
<td>6-8 weeks after the first picking of leaves (early October)</td>
</tr>
<tr>
<td>6.</td>
<td>Second weeding and inter-cultivation</td>
<td>5-6 weeks after the first picking of leaves (early October)</td>
</tr>
<tr>
<td>7.</td>
<td>Second picking of leaves</td>
<td>Two months after the first picking of leaves (mid October)</td>
</tr>
<tr>
<td>8.</td>
<td>Application of second dose of fertiliser @ 50kg N per ha.</td>
<td>3 weeks after the second picking of leaves (early November)</td>
</tr>
<tr>
<td>9.</td>
<td>Harrowing and weeding</td>
<td>November</td>
</tr>
<tr>
<td>10.</td>
<td>Third Picking of leaves</td>
<td>Two months after the second picking of leaves (early November)</td>
</tr>
<tr>
<td>11.</td>
<td>Third weeding and inter-cultivation</td>
<td>2-3 weeks after the third picking of leaves (early January)</td>
</tr>
<tr>
<td>12.</td>
<td>Fourth picking of leaves</td>
<td>Two months after the third picking of leaves (mid February)</td>
</tr>
<tr>
<td>13.</td>
<td>Fourth weeding and inter-cultivation</td>
<td>With receipt of pre-monsoon rains, 6-7 weeks after the fourth picking of leaves (early April)</td>
</tr>
<tr>
<td>14.</td>
<td>Fifth Picking of leaves</td>
<td>7-8 weeks after the fourth picking of leaves (early April)</td>
</tr>
<tr>
<td>15.</td>
<td>Harrowing and weeding</td>
<td>May</td>
</tr>
<tr>
<td>16.</td>
<td>Sixth and final picking of leaves</td>
<td>7-8 weeks after the fifth picking of leaves (May-June)</td>
</tr>
</tbody>
</table>
6.3.3 Spacing

Plant Spacing plays an important role in production quality leaf. Thereby populated mulberry garden can not yield high quality of leaf with quality. Wide spacing facilities, equal distributing sunlight, water, fertilizer are also important to improve yield.

The planting distance depends on the agro-climatic conditions and soil fertility, variety of mulberry planted etc.

Generally, varieties with profuse branching habit should be given wider spacing than those of the varieties with fewer branches. The interplant spacing within the row can be made narrower. In general wider spacing is adopted on flat lands, whereas on sloppy lands more close spacing is followed. This acts as a vegetative cover, reducing the soil erosion. The mulberry can be raised as a low to medium bushes or small trees in block plantation.

6.4 Mixed Cropping it is more useful for a small Farmer

Generally mulberry is grown as a monoculture crop. It can withstand different agro-climatic and environmental conditions to a large extent.

Mulberry can be very successfully grown as an intercrop in between the rows of tea garden and coffee as a shade plant. This will also help in producing good quality of mulberry leaves on experimental basis mulberry garden is grown as, intercrop in the wider space between the rows coconut plantation in Chennapatna, Kanakapura, Bangalore and Ramnagaram areas of Karnataka state in India.

Intercropping with beans, peas, vegetables and food crop other than wheat and Rice gains not only additional source of income to a sericulturist but also increases the fertility of waste land. However, attention should be given to mulberry which is the main crop.

6.5 Cultivation Methods

6.5.1 Rain fed Method

Under rain fed dry-farming conditions there is limited moisture content. Hence, the leaf quality as well as quantity of leaf harvest would be low. Therefore, wider spacing is given during plantation. Under rain fed conditions pit system of mulberry cultivation is taken up.
a. Pits System

Pits of 35 x 35 x 35 cm size are made at a spacing of 90 x 90 cm. 10 tones of organic manure/ha such as cattle dung compost is recommended to apply under rain fed conditions.

Method of rainfed planting

A. Pit Filling
B. Layout and pit making
C. Cutting Specification

Fig. 6.4 Plant Spacing for rain fed pit system

To a large extent mulberry is being cultivated under rain fed area. Three healthy cuttings should be planted in each pit in a triangular form with a distance of 15cm. Care should be taken to expose only one bud. In case of saplings, one sapling is enough per pit.

c. Inter-cultural Operations

Inter cultivation is taken up manually after mulberry plantation, when the crop is (5) months old. Ploughing is done between the rows.
6.5.2 Irrigated Method

Under irrigated conditions, plantation is taken up in pit system as well as row system. While planting under irrigated conditions the recommended variety of mulberry suitable to the area is taken up.

a. Spacing

In the row system of plantation the rows one made 60 cm apart. Mulberry cuttings or saplings are planted in the rows at a distance of 22 cms. In the pit system the rows are made 60cm apart and cutting or saplings are also planted at a distance of 60cm.

Ridges and furrows should be made at a distance of 60cm. The furrows should be 15cm. deep. Cuttings should be planted along the margin of ridges.

b. Planting

Two cuttings are planted at each spot along the margin of ridges. In case of saplings, only one is enough in a trench of 20-23 cm depth.

Fig. 6.5 Spacings
**Paired Row System:** This system is developed by CSR&TI Mysore, 3M Plantation spaced as (90+90+120)x(90+90+120), is most convenient method among farmers who follow mechanized methods in all cultivation practices to conduct large scale rearing.

![Paired row system](image)

**Table 6.1**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Spacing between Rows (mts)</th>
<th>Spacing between Plants (mts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pit System (Rain fed)</td>
<td>0.9-0.75</td>
<td>0.9-0.45</td>
</tr>
<tr>
<td>2. Row system (Irrigated)</td>
<td>0.45-0.60</td>
<td>0.45-0.06</td>
</tr>
</tbody>
</table>

**Mulberry cultivation practices in different parts of India**

Planting season varies in different parts. In Karnataka mulberry is planted with the onset of south western monsoon i.e., during July-August months. In West Bengal, cuttings are planted during November (late autumn) after the cessation of north-east monsoon rains. Plantation during rainy season results in rotting of cuttings.
In India, mulberry is under a wider range of spacing. In Jammu and Kashmir, huge trees are utilized by lopping the branches for collecting the leaves. In many places it is grown as a pure crop with closer spacing.

In West Bengal and Karnataka, it is grown as bush type. In rain fed areas of Karnataka it is raised under pit system with wider spacing. In Kolar division of Karnataka closer spacing is adopted. In West Bengal, “strip system”, if close plantation is practiced, where there is a heavy rainfall. In this method spacing of 0.6 m between the strips is made. In each strip two to three rows planted at a distance of 0.15m. The distance between each row is 0.15m.

Under irrigation, the row planting known as “kolar system” is followed. In this system rows and furrows are made at a distance of 0.30 to 0.45 m. On either side of ridges mulberry is planted at a distance of 0.1 to 0.15m between the plants along the row.

In rain fed areas of A.P., mulberry is cultivated in pit system. Spacing between the rows is 0.75 to 0.90m or 0.45 to 0.90m followed. Under irrigated conditions row system is followed, ridges and furrows are made at a distance of 30 x 60cm. Plantation is taken up on either side of ridges with a spacing of 10-25 cm between the plant to plant.
6.6 Weeds and Inter-Cultivation

6.6.1 Weeds

Fig. 6.8 Phyllanthera Niruri

Fig. 6.9 Achyranthus Aspera

Fig. 6.10 Euphorbia Geniculata

Fig. 6.11 Lagasco Molis
1. **Parthenium hysterophorus (wild carrot)**: It belongs to family Asteraceae. Common name is Congress grass or carrot weed. It is an annual herb. It is a noxious exotic weed. It is a native of America, West Indies. This has spread to many parts of India covering approx. 5 million hectares. Parthenium plants prefer moist, shady. It causes dermatitis and other allergies in human beings. The seeds are extremely light weight, and disseminated by wind, water birds and animals. Through its persistence and rapid spread it has become not only an agricultural weed, but a municipal weed as well.

**Phyllanthus Niruri**

1. It belongs to the family Euphorbiaceae.
2. It is herb.
3. Leaves are opposite.
4. Control by up rooting.

**Achranthus Aspera**

1. Achyranthus aspera belongs to the family Labiatae.
2. It is common weed in mulberry garden.
3. Stem is soft, leaves are simple, alternate and reticulate. Influence is verticellaster, flowers bisexual, zygomorphic.
Control: By uprooting.

**Euphorbia Geniculata**
1. Family: Euphorbiaceae.
2. It is a herb, commonly found in mulberry garden.
3. Leaves are alternate.
   Control: By uprooting and burning.

**Porthenium Histeroforus**
1. Family Composite
2. It is perennial herb, with simple, and much elongated lobed alternate.
3. Inflorescence is raceme type.
4. The flower is white with smell.
5. Reproduction through seeds
   Control: It can be control by uprooting and this destruction in reproductive stage.

**Legasco Mollis**
1. Family: Compositae
2. Flowers are female on the top
3. Leaves are apposite
   Control: Deep ploughing and weeding.

**Leucas Aspera**
1. It belongs to family Labiatae.
2. This is common weed in mulberry garden.
3. Stem is squire, soft; leaves are simple alternate and reticulate.
4. Inflorescence is verticellaster, flowers are bisexual, zygomorphic and bilabiate
   Control: By up rooting
2. *Cyprus rotundus* (Nugrass, purple nutsedge): It belongs to family cyperacae, common name nugrass. It is an erect, glabrous and very persistent perennial herb. It is considered as the world’s worst weed as it occurs in 52 crops in 92 in countries. It is a native of India. It is widely distributed throughout the tropics and subtropics. It is proposed by seed like nuts and under ground stems.
3. **Cynodon dactylon (Bermuda grass, Stargrass)**: It belongs to family Gramineae, commonly called Devil’s grass, Bermuda grass and stargrass, Bermuda grass and stargrass. It is a perennial grass water long runners which strike roots at the nodes and extensive underground rhizons. It occurs throughout the tropical, sub-tropical and semi-arid regions of the world. It is propagated by grains and underground stems.

4. **Phyllanthus niruri**: This weed belongs to family Euphorbiaceae. It is a glabrous annual herb. Leaves are small.

5. **Euphorbia hirta (Garden spurge, Asthma weed)**: Belongs to family Euphorbiaceae, commonly called as spurge and Asthma weed. It is a small, prostrate annual herb. Commonly found in tropics and sub-tropics both in moist and dry environments. It can be seen in cultivated lands, lawns, gardens and waste lands. It reproduces by seed. Cultivation hoeing and manual methods can control this weed effectively.

6. **Trianthema parthulacastrum**: Belongs to family Aizoaceae, common name Horse purslane, a prostrate much branched herb. Propagation by seeds. Generally when the cattle eat the seeds, the undigested seed comes out along the cattle dung when it is used as a manure in the field, the weed propagates.

7. **Xanthium strumarium**: Belongs to family Compositae. Common name Burd-weed. It is a coarse annual herb. Propagated by fruits.

8. **Tridax Procumbens**: Belongs family Compositae. It is a perennial herb. Propagated by achenes.

6.6.1.1 **Effect of Weeds on Mulberry**

Today there are only 15 species of plants are cultivated to produce food grains to meet the demand of 90% of world population. However, there are 2,50,000 species of plants are existing in the universe. There are at least 6,700 weeds are competing with the crop plants and thereby reducing the production capacity. Out of 6,700 weeds there are approx. 76 varieties of weeds are chronic and are severely damaging the production capacity of food grains.

Weeds compete with crop plants for nutrients, soil moisture, space and sunlight. Even in drought situation, they thrive better than crop plants. Weeds complete more than one generation and multiply their number in a span of one crop harvest. They compete with crop plants for water, fertilizers, soil nutrients, sunlight and thereby, damage the production of crop yield.
It is estimated that around 24-58 kgs of Nitrogen, 3-18 kgs of Phosphorus, 15-63 kgs of Potassium are lost per ha. for different agricultural crop plants due to weed attack.

Due to the presence of weeds in mulberry garden leaf yield lessens. Reduction in leaf yield directly depends on the degree of weed attack. The quality of leaf suffers a lot. The nutritive value comes down. Generally, when weeds spread over in the mulberry field. They also share the fertilizers, manures, soil nutrients, soil moisture from the field. There by the calculated quantity of FYM or fertilizer or applied irrigation for one acre/ha of mulberry would become insufficient. The complete calculation of crop yield goes wrong.

A sericulturist who can harvest 60-70 kg of cocoons from 100 DFLs by feeding high nutritive quality mulberry leaf could be able to harvest only 30-40 kgs by weed attack in the mulberry field.

Weeds become a major problem during drought. During drought moisture in the soil itself will be very less. Farmer when applies irrigation to mulberry. The quantity of water received by weeds is as good as mulberry, and even more sometimes. The quality of leaf harvested from such garden has less moisture. Leaf harvested from such garden can not be preserved for a long time, withering starts early. This leaf fed to silkworm does not result in good harvest of cocoon crop.

Mulberry growth rate comes down by weed attack from its normal growth rate. Weeds serve as alternate hosts to several crop insects, nematodes, pathogens. Insects such as aphids, thrips, weevils and stem flies survive on Brassica kaber (wild mastoid), Doucas carota (wild carrot) etc. Weeds such as Avena fortua (wild oats) and some perennial grasses harbour pathogens of black stem rust of wheat. By harboring there pathogens and insects and their attack on crop plants increases tremendously which results not only of crop damage, but also it increases the cost of their control. Financial burden increases on sericulturist and the expected profits come down drastically. Root zone of mulberry is susceptibility to attack by nematode pathogens.

Effects of weeds on mulberry results in

a. It reduces the moisture content in mulberry leaf.

b. Nutritive value becomes deficient.

c. Normal growth rate comes down drastically.
d. Reduction in crop yield.

6.6.2 Inter-Cultivation

All types of crops that are field grown are subject to weed competition. The weed competition is one of the most important factor in all types of crops. Efficient eradication of weeds increases crop production.

Weed problems vary from one crop to another, one farm to another.

Weed growth is more intensive in warm, humid and high rainfall areas than in hot dry and low rainfall areas.

Weeds can be controlled by

1. Physical method
2. Inter cultivation
3. Chemical method
4. Biological method

1. Physical methods

 Mechanical and manual weed control measures are as old as agriculture itself. In the recent years herbicide technology and weed management have developed much. Which are protective and cost effective, weed competition is maximum during early stages of crop growth. Growth rate of weeds will be more during the favorable environmental conditions. Weed competition varies from crop to crop.

 Manual weeding by digging, sucking, hoeing and pulling are the most common methods of weed control. Hand weeding is done by physical removal or pulling of weeds.

 Hoeing is highly effective means of weed control, the hoe would remain as one of the principal tools for weed control. Hand weeding is done by physical removal or pulling of weeds. Digging is very useful in case of perennial weeds to remove the underground propagating parts of weeds from the deeper layers of soil. Burning is an economical and practical means of controlling weeds. Tillage is done with implements drawn by animals or mechanical engines (tractors, tillers etc.). Extensive tillage operations which includes ploughing, disking, harrowing and leveling are undertaken to prepare soil. These operations help to expose the weeds towards sunlight which can be destroyed effectively.
Inter-row cultivation by hand rotary weeder is useful, time saving and more economical method of weed control than manual weeding. In inter-row cultivation by hand rotary weeder, it uproots the weeds and buries them in the mud. Application of green manure and by mulching also we can control the weeds effectively.

2. Inter Cultivation

For better growth of mulberry, two months after planting a eight hoeing and weeding should be given. Second weeding is done after another two to 3 months. There after inter cultivation should be adopted after every leaf/shoot harvest. Weeding helps in loosening of the soil which facilitates better growth of, root system. Further, the selection of quality seed, adopting new technology, cultivation of high yielding varieties is advised.

3. Chemical Method

It is another method of destroying the weeds and is mostly under use. Before using the chemicals, one should understand the precautions and method of usage of chemicals. To control Parthenium, one kg salt is added to 5 lts. of water and added to 5 gr of detergent soap. Ammonium nitrate, Monochloro acetic acid acts effectively for weed control.

Glycin with Ammonium sulphate mixture controls Cyperus rotundus, Cynodon dactylon effectively. Besides these, 2,4-D, Sodium salt, 2,4-D amine, Fluchloralin, Atrazine, and Diuron chemicals are used.

4. Biological Control

Biological weed control involves the utilization of natural enemies for the control of certain weeds. The main objective of biological control is not eradication but rather, reduction and regulation of weed population. Biological control may be defined as the action of predators, pathogens and parasites in maintaining another organism’s population density at a lower average level than would occur in their absence.

Herbivorous fish Tilapia Spp. effectively controls the algae and other weeds. The common carp (cyprinus carpia) a non-herbivorous fish, used for control of certain aquatic weeds. It is a mud-bottom feeder and control submerged aquatic weeds.

The cochineal mealy bug Dictylopius indicus is used to control opuntia vulgaris on par with nium hysterophorus. Biological control, applies to destroy the weeds alone.
Precautions in using in Weedicide

a) Soil treatment agent is sprayed evenly with automatic sprayer after removing the grass before budding after summer cutting.

b) Care should be taken that the chemical should not contact with young

c) Soil should not be dry and spray should have be carried soon after medium tilling. After it rains, soil should be allowed to become stabilized then the soil treatment agent should be sprayed.

6.6.2.1 Weeding Implements

1. Hand Weeder (hand cultivator)

Specification: It is made up of iron, fixed in a wooden handle, there are five finger like structures which are sharp known for hand grip. It is used for weeding and loosening the soil in mulberry fields.

2. Weeder or Khurpi

Specifications: Its blade is made up of iron. Blade is elaborated at one end, another end is fixed in a wooden handle. It is used for removal of weeds as well as loosening the mulberry fields.

3. Dobbins Duster

It is made up of iron sheet. It has a continuous handle, a blower pipe is fixed. It is arranged by a belt and a fan body. To dust out the chemicals used is only through outlet. It is used for dusting insecticides or pesticides and weedicides in the mulberry field.

4. Garden Rake

Specifications: Its body is made up of iron. It contains a handle and four rakes. It is used for weeding purpose of loosening the soil.

5. Mayer’s sprayer

Specifications: It is made up of brass. It contains a pumping rod with wooden handle, two belts and a inlet for pouring insecticides or pesticides. One end of the handle take attacked to the brass body and another to brass tube, which has a nozzle and there is a outlet for pressure release purpose. It is used for spraying insecticides or pesticides or weedicides.
6. Spade

Specifications: Made up of iron, it contains handle made up of wood and rake. Used for preparation of land.

7. Forked spade

Specifications: Made up of iron. It contains 3 sharp finger like structures fixed to a wooden handle. Used for weeding purposes.

8. Hook

Specifications: Made up of three iron hooks and a handle made up of wood. Used for weedy purpose
Besides these above the other weedy implements are wheel, pull push saw etc.

6.7 Pruning and Training

6.7.1 Pruning

Pruning is not deviating process rather it invigorates the plants into production phases leading to luxuriant growth and better leaf yield.

In temperate countries like Japan and Russia where cool climate conditions are prevailing, mulberry sprouts during spring (early April). It grows up to autumn (October) when leaf shedding starts. In winter (December-February) mulberry plant remains dormant. Pruning the mulberry plants is useful in adjusting the production period to synchronize with the leaf requirement for silkworm rearing. Pruning also helps in diverting the energies of plant for optimum production of foliage. Irregular branching of plant and many of the branches in adverse position may not get required nutrition and sunlight; thereby leading to wastage of foliage energy. Over crowding of branches on the top of plant persists. Only when pruning is carried out in excess or the cut wounds do not heal and leads to infecting and diseases. Pruning is also a technical process and carried out very carefully.

Main objectives of Pruning

i. To maintain proper shape and size of plant

ii. To make cultural operation easier.

iii. To provide proper aeration and sunlight.

iv. To maintain convenient height for harvest.
v. To induce higher foliage.

Pruning schedules are differently adopted according to the existing field condition and area under operation, which again depends upon various factors viz. technically climatic conditions.

6.7.1.1 Cut forms

The method by which the shape and form of mulberry plant is maintained is called a ‘cut form’.

By maintaining a specific shape of the plant, a guaranteed quantity of mulberry leaf can be obtained and this is possible by adopting pruning schedules.
This helps planning the rearing schedules and management part of work becomes easier. This will be possible only when pruning schedules are followed.

As said earlier the pruning schedules vary from place to place. In temperate regions of Japan the silkworms are reared in 2-3 seasons of the year. Accordingly the pruning schedules are practiced. Spring pruning is practiced for harvesting the crop in spring or autumn, summer pruning is for harvesting in autumn and spring.

Types of Cut forms:

i. Low cut or bottom pruning

ii. Medium cut or middle pruning

iii. High cut or top pruning

i. Low cut: In low cut form the length of the main stem is maintained below 50 cm. from the ground level.

Bottom pruning: In tropical climate of India where mulberry sprouts through out the year, their pruning season depends on two factors viz., the rate of rainfall and methods of leaf harvest. Under rain fed dry farming conditions, the plants are pruned once a year (during July-August) at a height of 10-15 cm from ground level. This is called “bottom pruning”. In Karnataka two bottom pruning is suggested, once in June and 2nd in November. This will help to harvest 5-6 crops 111 a year.

ii. Medium cut: In this type of pruning the length of the main stem is maintained one meter from the ground level.
Middle Pruning: Middle pruning is a method of cutting the branches of bush mulberry at a height of 45-60 cm from ground level during December-January.

Middle pruning is practiced to induce sprouting flower buds on the stem during winter months.

iii. High cut: Here, if it is above one meter above the ground level.

The maintenance of height varies from place to place.

Merits and demerits of various types of pruning

A. Merits of Low cut pruning

(a) Harvesting and preparing of mulberry cutting is easy and the stumps are maintained straight.

(b) Sprouting occur early, thereby harvesting rate increases.

(c) Occurrence of damage due to pests and diseases is very less. In case any infection is noticed it is easy to adopt control measure.

(d) The growth rate of shoots is early which enables the early harvesting.

(e) It has high utility value for rearing the summer and autumn silk worm, because hardening of leaves is delayed as the growth is rich even during late autumn.

Demerits

(a) During heavy rains, the mulberry leaves get soiled easily.

(b) Plants are susceptible to damage by frost and snow.

(c) Since, the plant age is shortened; occurrence of dwarf disease is high.

B. Merits of High cut pruning

(a) The quality of leaves is better. The age of the plant is also longer.

(b) Damage due to frost, snow is less and attack of diseases like dwarf disease is less.

(c) Leaves mature rapidly

(d) Water content in leaves is relatively low

(e) Damage due to floods is less.
Demerits

(a) It is difficult to manage adjustment of stump.
(b) Difficult in harvesting leaves.
(c) Rate of harvesting leaves is less.
(d) It takes too long time for the plants to get ready for harvest.
(e) The plants get easily damaged by wind and it is difficult to supplefl.1ent for the dry stumps.
(f) Plants get easily damaged by pests and diseases.

The merits and demerits of medium cut pruning will be in between the low-cut and high-cut pruning.

6.7.1.2 Adoption of forms of Pruning

Low-cut pruning is recommended for the warm regions and where the soil is shallow and the underground water is rich.

Medium-cut pruning is desirable in the regions where there are frequent floods and heavy rains.

High-cut pruning is recommended in cold regions where there are chances of snow damages and is also better to adopt where frequent floods and heavy rains and where there is underground water is poor.
6.7.2.2 Training

Systematic pruning to give a specific shape to a mulberry tree is called ‘training’. If there is no pruning to a mulberry tree, the tree grows naturally and the leaves cannot match to the stage of silkworms under rearing. Silk worm need a specific age leaves during different instar stages. Hence, it is difficult to harvest quality leaves suitable for different stages of silkworms from the naturally grown mulberry tree.

At the time of planting, the seedlings are cut to a height of 15cm above ground level. From this plant 3-4 branches chosen and are pruned so as to have 5-10cm length above the ground level. These branches are termed as primary branches. Middle pruning is practiced to induce sprouting of lower buds on the stem during winter months.

On these primary branches three secondary branches are retained. During the second year each plant you 9 branches. In the 3rd year during the spring rearing season all the branches are pruned at a length of 3cm from the fist. During the spring rearing season of the 4th year, the branches are harvested leaving a shorter length 1 to 2 cm from the fist. A similar harvesting process is repeated, and in a few years a “fist shape” appearance eventually gives place to the growth of 10-15cm long stout branches. This form of training is designed for harvesting of mulberry leaf for spring rearing.

After the leaf harvest for spring rearing the branches are pruned in May-June, when the plants grow fast and the pruning is called “Summer Pruning”. From summer pruned plants, ‘leaves are harvested for autumn and spring rearing. The branches are pruned in March, before spring sprouting of buds and this is known as “Spring Pruning”.

The very object of training is to get a suitable form to mulberry plants to get maximum leaf yield. This is achieved by adopting suitable pruning schedule.

Types of Training

a. First form  b. Non-first form

a. **First form**: In view of cutting mulberry plant each year at one place of the main stem. The top part of trunk gradually increases in diameter without any increase in height. This part becomes thick and takes the shape a fist after a few years. Hence it is called fist form. The latent buds at the base of fists sprouts into shoots. In this method it is easy to control the mulberry disease and pests. This is disadvantageous because new buds will not form their leaf yield will be less. Hence it is not followed by the farmers.
b. **Non-first form**: In this type of training, branches are cut at a level higher than the branching point every year. Thereby the branching point of the shoot increases in its height every year. It does not resemble a fist. Hence, it is called non-fist form. This method is advantageous and popular among the farmers.

For both fist and non-fist forms of training, low, middle and high-cut pruning can be followed.

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**Irrigation**

### 6.8 Principles of Irrigation

Water is essential for plants like all other living systems. Water contributes as much as to the essential properties of life as do the more
complex proteins, carbohydrates etc. It is a fact that, water is essential for most of the physiological reactions in plant tissues and in its absence plant life does not exist. Water is essential during preparation of land, plantation and so on.

Quantity of water required for each crop differs, which may depend upon the variety of crop, type of soil, age of crop, moisture content of soil etc.

Requirement of water (WR) =

Use of water + Loss due to usage + Emergency usage of Water

\[
WR = A + B + C
\]

Water holding capacity depends upon the texture of soil. The growth rate of a plant progressively decreases as the soil moisture approaches the wilting point.

6.8.1 Physical classification of soil water

From a physical point of view the terms a) gravitational water b) capillary water and c) hygroscopic water are identified. The forms of soil moisture are;

a. **Gravitational Water**: Gravitational water occupies larger soil pores (macro pores) and this water moves downwards very rapidly due to the force of gravity. Water in excess of field capacity is termed as gravitational water. Gravitational water is of no use to plants.

b. **Capillary water**: Capillary water is held in capillary pores (micro pores). Capillary water is retained on soil particles by surface force. The molecules of capillary water are free and mobile and are present in a liquid state. Hence it evaporates easily at ordinary temperature. Capillary water is available water for plant growth.

c. **Hygroscopic water**: The water held tightly on the surface of soil colloidal particles is known as hygroscopic water. It is essentially non-liquid and moves primarily in the vapor form. Hygroscopic water held so tenaciously by soil particles that plants cannot absorb it. Unlike capillary water which evaporates easily at atmospheric temperature, hygroscopic water cannot be separated from the soil unless it is heated.
The three classes of water are, however, very broadly defined and do not represent accurately the soil-water relationship that exists under field conditions. Hence, two more soil constants viz., field capacity and wilting coefficient have

i. Cumulative evaporation of water from water surface

ii. Soil moisture tension-cum-physiological growth of crop

All the above factors vary from place to place. The evapo-transpiration loss varies according to the mulberry growth stage. In mulberry the evapo-transpiration loss has been worked out to 4-5 mm per day. The climate conditions and soil condition varies more in each area.

6.8.2 Soil moisture

The amount of water (moisture) in the soil is limited by its field capacity and wilting coefficient. The amount of water that can be stored in the soil depends upon the soil texture and soil structure. Hence the water holding capacity of soil is not uniform in all the places. Before, application of irrigation to the plant it is necessary to see the field capacity.

The soil moisture can be measured by various methods and it is essential to know the soil moisture capacity each plot (area) before establishing the mulberry plantation.

Methods of measuring soil moisture

a. Use of Tensiometer

b. Gravimetric method

c. Electronic properties of porous blocks

d. Neutron method

For mulberry it is necessary to bring the soil moisture level to field capacity upto 3 feet in depth. In mulberry plantation about 50-75 mm per acre of water has to be applied uniformly to bring the moisture level upto root zone excess application of water gets wasted either by runoff or by percolation.

Mulberry soil moisture content

Obtain a moist sample, dry it in an oven at 105°C until it loses entire water, then determine the percentage of moisture.

\[ \text{Moisture content} \% \ (MC) = 100 - \text{DM} \ (\text{Dry Matter content}) \]
DM % = Dry weight of soil / fresh weight of soil x100

Besides the above gravimetric method by electrical conductivity method also soil moisture can be calculated.

Soil moisture is not a problem in temperate regions like Japan, where the rainfall is ranging from 1000 to 2500 mm per year. Therefore, now it is clear that soil moisture should be maintained by application of water in any of the irrigation methods and avoids excess irrigation.

6.9 Water Requirement for Mulberry

As seen from the preceding paragraph it is clear that the requirement of water for mulberry is at a rainfall of 600-2500 mm. An average of 50 mm once in ten days of rainfall is considered as ideal for mulberry.

In south India (Karnataka) the rainfall is hardly 600 mm per annum and this range is not distributed evenly in all the areas. Hence, the mulberry growth suffering a lot for soil moisture. Therefore, supplementing irrigation is needed for better growth, where the mulberry crop is reared under the monsoon rains.

The amount of water received to be irrigated over a period of one year is about 125-150 cm. The evapo-transpiration loss in mulberry is 4-5 mm per day. One more important factor is to avoid excess irrigation of water, excess irrigation not only leads to wastage but also leads to water logging and salt deposition and expensive.

Mulberry crop should be allowed extract more than 60-70% of available water from soil, for better foliage and regulated plant growth.

6.9.1 Frequency of Irrigation

Frequency of irrigation depends upon many factors viz., agro-climatic conditions, growth phase of plant, soil-type etc. In India it varies from place to place. For clay loam soils 15 day once and Sandy soils 8-10 days.

During November-April, 12-15 irrigations are required to supplement the water scarcity in tropics. Mulberry grows throughout the year in India. Therefore, during drought period supplementary irrigation should be given. Further, it is noted that during active growth period of mulberry plant (i.e. sprouting and foliar) the crop has to be irrigated frequently.

The sources of water for irrigation are;

1. Open well
2. Tube well
3. Canals (streams)
4. River or Tanks
5. Rainfall

Though, water is available in various places and becomes the source of irrigation. It involves expenditure and is complex.

Flow Chart Types of Irrigation

6.10 Methods of Irrigation

1. Basin method
2. Flat bed method
3. Furrow method
4. Sprinkle method
5. Micro irrigation

Broadly the above indicated methods of irrigation are mostly practiced besides the different methods of irrigation.

1. **Basin method**: It is particularly adopted for tree plantation. In this system of irrigation water from supply source is allowed to flow into the basin around the trunk. The diameter of basin varies according to the size and age of the tree (1.0-1.5m)

   Advantages: a. Evaporation loss is less.
b. Soil is not eroded  
c. Water is not wasted 

Disadvantages: a. laborious  b. costly

2. **Flat bed method**: In this method the field is divided into rectangular beds with bunds all around and channels on the sides. (3.5 x 2.0 mm or 4.0 x 6.0mm).

a. Suitable for all types of soils.  
b. No soil erosion  
c. Relatively economic in water usage.  
d. Low wastage of water due to runoff.  
e. Irrigation is quick

a. More laborious  
b. Involves more wastage of space.

3. **Furrow method**: In this method the field is laid into a series of ridges ad furrows as in row system the water flows through furrows and the ridges are moistened by capillary movement of water.

**Advantages**

a. More efficient from economic point of view  
b. Suitable for wider and closer spacing plantation.  
c. Less evaporation of water from soil surface
d. ridges carry the system hence sufficient air is available for the roots to develop.

e. furrows drain the excess water during rainy seasons.

Fig. 6.21 Furrow Method

Advantages:

a. Less water usage
b. Most efficiently water can be used
c. Uniform distribution of water in the field.
d. It can be followed in sloppy and shallow lands.
e. The percolation in sandy and porous lands can be avoided.
Disadvantages

a. High cost
b. Technical knowledge required
c. Laborious.

5. Micro Irrigation: A new method of irrigation to minimize the loss of water is micro-irrigation. In traditional methods of irrigation, water is passed through open channels and a lot of water is lost through soil seepage, surface runoff and evaporation. In micro-irrigation, water from one source is passed through closed pipelines and are conveyed to the plants.

(i) Drip Irrigation: This system of irrigation, water is supplied directly to the root zone through pipelines directly from the source. Water is discharged through nozzles (pores) at the rate of 4-6 litres/hour.

Advantages

a. Useful to the areas where there is scarcity of water.
b. Can save labour
c. Water loss by percolation and evaporation is reduced.
d. No loss of fertilizers or organic manures.
e. Weeds can be reduced.

Disadvantages

a. Installation cost is higher
b. Inferior quality nozzles (pores) stuck up with dust/salt deposits

(ii) Micro Jet: Water in this method is sprinkled 1-4 mts. long. Water discharging capacity in this method is 5-160 ltrs/ha. These are recommended for large tree crops like orange, mango etc.

(iii) Micro Sprinkler: This is also alike sprinkler, however, discharge of water 28-223 lts/ha. And it is sprinkled to a distance of 0.9-4 mts.

(iv) Bubbler Irrigation
i) This is the latest irrigation system.
ii) In this method, water can be discharged as per the requirement.
iii) Cumulative evaporation of water from water surface
iv) Soil moisture tension-cum-physiological growth of crop

All the above factors vary from place, to place. The evapo-transpiration loss varies according to the mulberry growth stage. In mulberry the evapo-transpiration loss has been worked out to 4-5 mm per day. The climatic conditions and soil condition in each area factors more.

**High Lights in Review**

- Spacing between plant to plant plays an important role in product quality of leaf.
- Under Rainfall condition pit system is taken up with pit size of 35X35X35 at a spacing of 90X90cm 10 ton of organic Manure/Ha is recommended.
- Under irrigation conditions rows are made 60cm apart. Cutting plants in the rows at a distance of 22cm. In irrigated pit system rows are made at a distance of 60cm. Furrows depth should be 15cm.
- Weeds are unwanted and undesirable plants. Weeds complete with main crops for nutrients, soil moisture, light, aeration, space and fertilizers etc.
- Weeds are serves as alternate hosts to several crop insects, nematodes, pathogens etc.
- Weeds can be controlled by (i) Physical methods and (ii) inter cultivation methods(iii) chemical methods and (IV) Biological methods.
- Methodical cutting of certain mulberry branches periodically is called pruning.
- The main objects of pruning is to maintain proper shape, size, Convenient size and to synchronal the leaf production.
- By the application of water to soil, to supply moisture essential for plant growth. Capillary water is available for plant growth.
- The amount of water (moisture) in the soil is limited by its field capacity and wilting co-efficient.

**Short Answer Type Question**

1. What is the recommended spacing in mulberry cultivation under Rain fed and irrigated conditions.

2. Define Weeds.
3. What is pruning.
4. What is first form?
5. What is Training?
6. What is Irrigation?
7. Define watershed.

II. Essay Type Questions

1. Write notes on Irrigated mulberry planting methods.
2. Write notes on Rain fed Mulberry planting methods.
3. Write any five weeding equipments and explain its uses.
4. Describe weed control methods.
5. Define pruning and explain impact of pruning.
6. Write notes on Training.
7. Write notes briefly on irrigation methods.
8. Write short notes on (a)Kurpi b) Fork c) Hook d) First form e) Drip-Irrigation f) Basin method (g) High Cut.

Numerical Questions

1. Identify the different weeds. Collected it and prepare herbarium.
2. Adopt low, mid and high cut pruning methods in mulberry garden.
3. Adopt weed controlling methods physical, chemical and Biological control methods.
4. Adopt Drip and sprinkler methods of irrigation in mulberry garden.
Structure

7.1 Introduction

7.2 Manures

7.3 Fertilizers

7.4 Vermi Compost

Learning Objectives

After studying this unit the student will be able to

- Understand about manures, and classification of manures
- Understand about Fertilizers and different types of Fertilizers
- Understand about Vermi Compost

7.1 Introduction

Plants need several kinds of food for their normal healthy growth, which are obtained from air, water and soil. The environment is an outdoor chemical factory where the plant get different energy and nutrients from sunlight, soil and water and convert them into their own food and for man. Here are food elements or nutrients which plants need for their growth are obtained partly from the soil, an organic matter and mineral particles. The soil organic
matter was derived from decomposed plants and then plants absorb the food elements from the organic matter. The nitrogen present in the soil and the organic matter, in the form of protein is commonly called as ‘primary plant food elements in the soil.

These plant nutrients are lost from the soil in different ways. Large quantities are removed from the soil due to harvest of crops. Weeds absorb considerable amounts of nutrients from the soil. Nutrients are also lost by leaching and erosion. Nitrogen is also by volatilization and denitrification. Since soil is the basic source of plant nutrients to meet, nutrients are applied as manures.

Manures are plant and animal wastes that are used as sources of plant nutrients. They yield nutrients after their decomposition. Manures can be grouped into bulk organic manures and concentrated organic manures based on concentration of the nutrients.

Plants need 16 elements for their growth and completion of life cycle. The plant food elements in the soil are found both in the organic matter and mineral particles. The nitrogen present in the soil is in the organic matter and is present the form of protein or related compounds. The nutrients present in the mineral particles of the soil are derived from the rocks and minerals from which the soil was formed. The elements are carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, iron, manganese, zinc, copper, baron, molybdenum and chlorine. Plants also absorb sodium, cobalt, vanadium and silicon for special purpose. All these elements are not required for all plants, but all have been found essential for one plant or the other. The carbon and oxygen are derived from \( \text{CO}_2 \) and assimilated in photosynthesis. Expect C, H, O others are called mineral elements. Above all, the primary plant food elements i.e., nitrogen, phosphorus, potassium are observed from the soil. The deficiency of the elements makes it possible for the plant to complete the vegetative or reproductive stage of its life cycle. The elements must have a direct influence on the plant and directly involved in the nutrition and metabolism of the plant.

For proper growth and development of crops, the nutrients must be present in the soil in available form, usable by plants. The concentration of the nutrient must be optimum for plant growth. Deficiency as well as excess of any nutrients usually causes limiting of harmful effects especially in the case of micronutrients which are required in small quantities. There must
be a proper balance among the concentrations of the various soluble nutrients in the form of manures and fertilizers.

7.2 Manures

The plant and animal decomposed bodies are the source of organic manure. It is necessary for plants growth and high yield. Soil fertility depends on the content of nutrients present. A fertile soil is one which supplies enough of necessary plant food elements to produce large crops of good quality. Most of the soils are fertile when they are virgin or first brought under cultivation. The quality of organic matter in the soil can be increased by adding FYM, compost and green manure. Most soils contain more food elements which are not able to supply them quickly to meet the requirements. Hence it is necessary to add organic manures to the soil.

7.2.1 Bulky Organic Manures

These contain small quantities of plant food elements and do not contribute much to the increase of plant food supply in the soil. Further these are applied in large quantities. The value of these manures however, depends on the amount of humus they produce or add to the soil.

Classification of Manures

Organic Manures
- Bulky Organic Manures
  - Farm Yard Manure
  - Compost Manure
  - Poultry Waste Manure
  - Night Soil
  - Sewage and Sludge
  - Gobar gas plant manure
  - Silk worm litter
- Concentrated Organic Manures
  - Oil Cakes
  - Blood meal
  - Meat Meal

In-Organic Manures
- Green Manures
  - Biofertilizers
  - Wormy Compost
- Nitrogen
- Phosphorous
- Potash
- Micro Nutrients
Advantages

1. They apply plant nutrients including micronutrients.
2. They improve soil physical properties like structure, water-holding capacity etc.,
3. Increase the availability of nutrients.
4. Carbon dioxide released during decomposition act as a CO$_2$ fertilizer.
5. Plant parasitic nematodes and fungi are controlled to some extent by altering the balance of micro organisms in the soil.
6. Provide food for soil microorganisms. This increases activity of microbes which in turn help convert unavailable plant nutrients into available forms.

7.2.1.1 Farmyard Manure

It refers to the decomposed mixture of dug and urine of farm animals along with the litter (bedding material) and left-over material from roughages or fodder fed to the cattle. It is one of the most commonly used manure. On an average well decomposed farmyard manure contains 0.5 percent N, 0.2 percent P$_2$O$_5$ and 0.5 percent K$_2$O. Thus it is one of the most important agricultural by-products, It is useful for application to all soils and on all crops. It has a residual effect i.e., it’s beneficial effect on the crop is not confined to the season of application but persists over a number of years. The micro and macro nutrients fertilize the soil and improve crop yield. This effect is very important in case of most of our arable land. It increases soil humus. The FYM consists of two original components- the solid or dung and liquid or urine. On an average, the animals give out three parts by weight of dung and one part by weight of urine. The fertilizing constituents (N, P$_2$O$_5$, K$_2$O) of the excreta of various animals come from the food eaten by them. The urine contains one percent nitrogen and 1.35 percent potassium. During storage also nutrients are lost due to leaching and volatilization. Thus trenches of size 6-7.5 metre length, 1.5-2 meter width and 1 meter deep are dug to store farm by-products. The litter, refuse along with dung is collected and placed in the trench. It is necessary to keep the manure trench compact and moist to increase the quantity of FYM and it will decompose well. Well decomposed FYM is brownish –black in color, powdery and without the smell of fresh dung. Generally nitrogen is lost from this FYM which can be prevented by spearing 2-3 days. One tone of cow dung requires 25 Kg of super-phosphate.
Table 7: Micro Nutrients in Animal Dung – organic Fertilizers Manure/Fertilizer

<table>
<thead>
<tr>
<th>Manure/Fertilizer</th>
<th>Dry matter in ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitro Chalk</td>
<td>B     Mn   Cu   Zn</td>
</tr>
<tr>
<td>Sodium Nitrate</td>
<td>0     24   22   15</td>
</tr>
<tr>
<td>Ammonium sulphate</td>
<td>0     08   03   01</td>
</tr>
<tr>
<td>Super Phosphate</td>
<td>06    06   02   0</td>
</tr>
<tr>
<td>Potassium Sulphate</td>
<td>11    11   04   150</td>
</tr>
<tr>
<td>Potassium Chloride</td>
<td>04    06   04   02</td>
</tr>
<tr>
<td>Cow dung</td>
<td>14    08   03   03</td>
</tr>
<tr>
<td></td>
<td>20    410  62   120</td>
</tr>
</tbody>
</table>

FYM is the best resource for soil micro nutrients. Fresh cow dung has macro nutrients in addition to micro i.e., zinc, manganese, iron, baron in large quantities when compared to synthetic organic fertilizers.

<table>
<thead>
<tr>
<th>Excreta</th>
<th>Percentage of N</th>
<th>P$_2$O$_5$</th>
<th>K$_2$O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cows and Bollocks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dung</td>
<td>0.40</td>
<td>0.20</td>
<td>0.10</td>
</tr>
<tr>
<td>Urine</td>
<td>1.00</td>
<td>Trace</td>
<td>1.35</td>
</tr>
<tr>
<td>Sheep and goats</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dung</td>
<td>0.75</td>
<td>0.50</td>
<td>0.45</td>
</tr>
<tr>
<td>Urine</td>
<td>1.35</td>
<td>0.50</td>
<td>2.10</td>
</tr>
<tr>
<td>Horses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dung</td>
<td>0.55</td>
<td>0.30</td>
<td>0.40</td>
</tr>
<tr>
<td>Urine</td>
<td>1.35</td>
<td>Trace</td>
<td>1.25</td>
</tr>
<tr>
<td>pigs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dung</td>
<td>0.55</td>
<td>0.50</td>
<td>0.40</td>
</tr>
<tr>
<td>Urine</td>
<td>0.40</td>
<td>0.10</td>
<td>0.45</td>
</tr>
</tbody>
</table>
From the point of soil fertility the excretes of various farm animals is important for the supply of N, P$_2$O$_5$, K$_2$O and organic matter. Urine of all animals contains more percentage of nitrogen and potash, compared to dung. Among various farm animals, horses produce large quantity of excreta per year. The cows on an average produce 42-46 Kg of nitrogen, 10-14 Kg of phosphorous, and 34-46 Kg of potassium per head annually in their dung and urine. Likewise a bullock can produce 60 Kg nitrogen, 15Kg phosphorus, 50 Kg potash. Thus every 10 tones of FYM contain 50Kg nitrogen, 20 Kg phosphorus, 50Kg potash.

Partially rotten farmyard manure has to be applied three to four weeks before sowing while well rotten manure can be applied immediately before sowing. The practice of leaving manure in small heaps scattered in the field for a very long period leads to loss of nutrients. The entire amount of nutrients present in farmyard manure is not available immediately. About 30 percent of nitrogen, 60-70 percent of phosphorous and 70 percent of potassium are available are to the first crop.

For mulberry 10 tones of farmyard manure for the rain fed crop and 20 tones for irrigated crop are recommended for one hectare of mulberry per year.

### 7.2.1.2 Compost

It is a mass of rotted organic matter made from waste. This process is to decompose plant reduces in a heap or pit to bring the plant residues are applied directly to the soil readily available from. If these plant residues are applied directly to the soil without decomposition, they are likely to be injurious to the crop. Compost is also useful in converting harmful waste products like sewage into a product that is safe to handle and use. Compost resembles ordinary farmyard manure in appearance, properties and manual value.

There are different methods of composting based on whether the process is aerobic or anaerobic. The residues usually used in compost have a carbon nitrogen ratio of 40-1 which is reduced to 10-12 after composting. If this ratio is may need some nitrogen to start with. The average nutrient content of farm compost is 0.5 percent N, 0.15 percent P$_2$O$_5$ and 0.5 percent K$_2$O. The nutrient value of farm compost can be increased by application of super phosphate or rock phosphate at –10 kg/t of raw material at the initial stage of filling the compost pit. The compost made from tow refuses like night soil, street sweepings and dust-bin refuse is called town compost. It contains 1.4 percent N, 1 percent P$_2$O$_5$, and 1.4 percent K$_2$O. In the village compost,
the amount of nitrogen varies from 0.4-0.8 percent, P$_2$O$_5$ from 0.3-0.6 percent and potash from 0.7-1.0 percent.

Compost is made by placing farm wastes in trenches of suitable size i.e., 4.5-5m long, 1.5-2m wide and 1-2m deep. The waste is dumped layer by layer. Each layer is moistened by sprinkling cow-dung slurry or water. Trench is filled up to a height of 0.5m above the ground. In *Bangalore method* the decomposition at first is aerobic raising the temperature, then the decomposition is semi-aerobic and slows down. The compost will be ready in about six months. Compost is applied to mulberry fields to partially meet the manurial requirements and help to reduce the cost of inputs.

### 7.2.1.3 Night Soil

It is solid and liquid excreta of human beings. It is rich in NPK than FYM and compost. Fresh night soil has 22 percent organic matter, 29 percent minerals, 5.5 percent nitrogen, 4 percent phosphorus, 2 percent potassium. This manure is widely used in China and Japan. But India a limited extent it is applied directly to the soil in trenches. The night-soil is deposited and covered over on top with a layer of earth. Such storage is called “poudrette system”. Since the material formed in the above trenches after they become dry is called as poudrette. Mixing of night soil with equal volume of ash and powdered charcoal produces material contain 1.3 percent nitrogen, 2.8 percent phosphorus acid 4.1 percent potash and 24.2 percent lime. Addition of 4050 percent of saw dust to night soil yields a dry, acidic poudrette which contain 2-3 percent nitrogen.

### 7.2.1.4 Poultry Manure

It is of the best manure. The excreta of birds ferment very quickly, If left exposed 50 percent of nitrogen is lost within 30 days. It contains higher nitrogen and phosphate than any other bulky organic manure. It has 3.03 percent N, 2.63 P$_2$O$_5$ and 1.4 percent K$_2$O. This manure has to be applied directly to the field.

### 7.2.1.5 Sewage and Sludge

In the modern system of sanitation adopted in cities and towns, human excreta are flushed out with water which is called sewage. The solid part in the sewage is called sludge and liquid is swage water. Both of these components are used to increase crop production. But it is necessary to separate these two components and are given a preliminary fermentation and oxidation treatments to reduce the bacterial contamination, offensive smell and also reduce C : N ratio of the solid part. The activated sludge and
on dry weight basis contains 3-6 percent nitrogen, about 2 percent phosphorus and 1 percent potassium. The activated sludge and the effluent can be used with safety for manuring and irrigating all field crops except vegetables which are eaten raw or uncooked.

7.2.1.6 Others

The nutrient contents in sheep and goat droppings are very high FYM and compost. It contains 3 percent N, 1 percent $P_2O_5$ and 2 percent $K_2O$. The sweeping of sheep or goat heads are placed in pits for decomposition and later applied to the plants, but nutrients found in urine are wasted. But in sheep pruning wherein sheep and goats are allowed to stay overnight in the field thus urine and fecal matter is directly incorporated to a shallow depth by running cultivator.

**Table 7.3**

An example of scheme for application of farm animal wastes on a mulberry field

<table>
<thead>
<tr>
<th>Suitable amount</th>
<th>In terms of N Kg N/10a/year</th>
<th>In term of material t/10a/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>For winter application</td>
<td>Chicken droppings</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>Raw pig waste (urine &amp; droppings, mixed)</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>Pig manure (droppings)</td>
<td>90</td>
</tr>
<tr>
<td>For split spring summer application</td>
<td>Chicken droppings</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Raw pig waste</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Pig Manure</td>
<td>60</td>
</tr>
<tr>
<td>For combined use with chemical fertilizer</td>
<td>Chicken droppings</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Raw Pig waste</td>
<td>45</td>
</tr>
<tr>
<td>Precautions</td>
<td>Pig Manure</td>
<td>45</td>
</tr>
</tbody>
</table>

1. These manures must be applied on mulberry fields for grownup silkworms, with good drainage
2. The manure should be mixed with soil after application
3. When combined with chemical fertilization, the entire amount for the year
4. Must be applied either in spring of summer
Note: For calculating the annual requirement of these *** of chicken droppings raw pig waste and pig manure was taken to be 1.43%, 0.27% and 0.8% respectively.

Like zinc, sulphur and iron. Every year a plant can yield 4-8 tons manures. The dry manures contain 1.6-1.8 percent nitrogen, 1-1.2 percent phosphorus, 0.8-1.2 percent potash.

7.2.1.7 Gobar Gas Plant Manure

The cow dung is utilized to generate methane, carbon dioxide, hydrogen gases are utilized for various purposes. But reduces of this process are utilized as manure. Since this manure is formed after decomposition contains high nitrogen. It also contains phosphates, potash and manure of micro nutrients.

7.2.1.8 Silk worm litter

The silkworm litter is also used as manure which has good amounts of nitrogen, phosphorus, potash besides micro nutrients.

7.2.2 Concentrated Organic Manures

These are organic in nature and contain high percentage of nitrogen, phosphorus, potash compared to bulky organic manures. This is also known as organic nitrogen fertilizer. After application these manures are converted through bacterial action into readily usable ammonia called nitrogen and nitrate nitrogen. These manures are slow in action but available for a longer period. The following are the different, common concentrated organic manures.

7.2.2.1 Oil cakes

The remaining solid portion obtained after oil extraction from oil seeds is called oil cake, can be used as manure. The oil cakes are of two types. Edible oil cakes are fed to livestock and non-edible oil cakes are not fit for feeding but both can be used as manure. The nutrients of oil cakes after mineralization are made available to crops after 7-10 days of application. Cakes are powdered for easy spreading and decomposition. In addition to nitrogen all oil cakes contain small percentages of phosphorous and potash. Oil cakes are quick acting organic manures.

Table 7.4 Average Nutrient Contents of Principal Oil Cakes

<table>
<thead>
<tr>
<th>Name of Oil Cake</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Non-Edible Oil cakes</strong></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>P₂O₅</td>
</tr>
<tr>
<td>Castor cake</td>
<td>4.3</td>
</tr>
<tr>
<td>Cotton seed cake</td>
<td>3.9</td>
</tr>
<tr>
<td>Un decorticated</td>
<td></td>
</tr>
<tr>
<td>Karanj or honge cake</td>
<td>3.9</td>
</tr>
<tr>
<td>Mahua or ippi cake</td>
<td>2.5</td>
</tr>
<tr>
<td>Neem cake</td>
<td>5.2</td>
</tr>
<tr>
<td>Sanflower cake</td>
<td>4.9</td>
</tr>
<tr>
<td>Un decorticated</td>
<td></td>
</tr>
<tr>
<td>Undi punna</td>
<td>3.6</td>
</tr>
<tr>
<td>Edible oil cake</td>
<td></td>
</tr>
<tr>
<td>Coconut cake</td>
<td>3.0</td>
</tr>
<tr>
<td>Cotton seed cake</td>
<td>6.4</td>
</tr>
<tr>
<td>decorticated</td>
<td></td>
</tr>
<tr>
<td>Groundnut cake’</td>
<td>7.3</td>
</tr>
<tr>
<td>Linseed cake</td>
<td>4.9</td>
</tr>
<tr>
<td>Jambo cake</td>
<td>4.9</td>
</tr>
<tr>
<td>Niger cake</td>
<td>4.7</td>
</tr>
<tr>
<td>Rape seed cake</td>
<td>5.2</td>
</tr>
<tr>
<td>De corticated</td>
<td>7.9</td>
</tr>
<tr>
<td>Seasame or til cake</td>
<td>6.2</td>
</tr>
</tbody>
</table>
7.2.2.2 Blood Meal

Dried blood or blood meal contains 10-12 percent nitrogen and 1-2 percent of phosphoric acid and one percent potash. It is very quick acting manure and is effective on all crops on all types of soil. Adult cattle give about 13.6 kg of bloods which have to be collected at slaughter-houses and dried to use.

7.2.2.3 Meat Meal

Waste meat is cooked and dried to get manure. It is quick acting and effective for all crops. Meat meal contains about 10.5 percent nitrogen, 2.5 percent phosphoric acid and 0.5 percent potash. A dead animal gives 36-45 kg of meat when dead.

7.2.2.4 Fish Meal

Non-edible fish are used to prepare fish meal. It is also quick-acting manure. It has 4-10 percent nitrogen, 3-9 percent P2O5, and 0.3-1.5 K2O. Fish blood has 5-8 percent nitrogen, 4-6 percent phosphoric acid. The fish are dried and powdered to use as manure.

7.2.2.5 Horn & Hoof Meal

A stout animal gives about 6-8 pounds of horn and hoof which cooked, dried and powdered which contains 13 percent nitrogen.

7.2.2.6 Bone Meal

It is used as phosphate fertilizer, available in two forms raw bone meal and steamed bone meal. The raw bone meal is crushed form contains 20-25 percent of phosphoric acid 3-4 percent nitrogen. The bones are to be powdered to 3/3:2/1 size particle which releases nutrients on application in the soil. Steamed bone contains 25-30 percent of phosphoric acid and 1-2 percent nitrogen. Steaming increases the percentage of phosphoric acid and reduces nitrogen. This also decomposes more readily than raw bone meal. This manure is better for acidic and aerated soils which have good drainage. It is less effective on heavy clay and calcareous soils. The lime content of bone reduces the acidity of soil.

7.2.3 Green Manures

It is another method of adding organic matter to the soil. A leafy crop, more usually a legume is ploughed in and mixed with the soil when it is about to flower. It is called green manuring. It is done in two ways by growing green manure crops and burying in the same field, by collecting
green leaf twigs. Leguminous crops are commonly used for green manuring as they fix atmospheric nitrogen and add nitrogen to the soil in addition to organic matter. When there is sufficient moisture in the soil the green manure crop decomposes quickly.

Green manure contains 0.5 -0.7 percent nitrogen, 0.1-0.2 percent phosphorus, 0.6-0.8 percent potash. It adds lot of humus to the soil. This manure promotes the activity of soil micro-organisms, increase the chemical action of the soil and plant food is made available. It improves the structure and water holding capacity of the soil. It reduces the run off and soil erosion. They also reduce the demand of farmyard manure for which there is great demand in agriculture. An application of superphosphate or bone meal to the green manure crop further adds to its manurial value. Green manure brings nutrients from deeper layers to top layers. In the off-season green manure reduces weed proliferation and weed growth. It helps in reclamation of alkaline soils and controls root-knot nematodes.

The commonly used green manure crops in mulberry plantation are Sann hemp (Crotolaria juncea), Horse gram (Dlichos biflorus), Dhaincha (Sesbaniate aculeata), neem, mahua, wild indigo, glyricidia, karanji (Pangamia glabra), subabul, pillipesara (Phaesolus trilobus), guar (Cyamopsis tetragonoloba), Terminalia, Cassia tora.

One ton of green manure yields about 4kg of nitrogen. Depending on the type of crop 10-20 tons of green manure is obtained per hectare. This will improve 30-50 percent of production.
Fertilizers are inorganic materials of concentrated nature and are applied to the plants to increase the supply of one or more essential plant nutrients which are listed above. These are called nitrogenous fertilizer which contain only one nutrient are called straight fertilizers and those which have two or more nutrients are called complex fertilizers. Fertilizers are also commonly known as chemical or artificial manures.

Depending on the quantity of nutrients present in plants are grouped into basic, macro and micro and macro nutrients. Basic nutrients viz. carbon, hydrogen and oxygen constitute 96 percent of total dry matter of plants. The macro nutrients are required in large quantities. They are N, P, K, Ca, Mg and S. Among these N, P, K are called primary nutrients and Ca, Mg, S are secondary nutrients. Micronutrients are required in small quantities. They are Fe, Zn, Cu, B, Mn, Cl.

Based on the functions, nutrients are grouped into four.

Elements that provide basic structure to the plant are C, H and O.

N, S, P is useful in energy storage, transfer and bonding. These are accessory structural elements which are more active and vital for living tissues.

K, Ca and Mg are necessary for charge balance and act as regulators and carriers.

The remaining elements are involved in enzyme activation and electron transport and called as catalyzers and activators.

However, the mobility of nutrients in the soil has considerable influence on availability of nutrients to plants and method of fertilizer application. For which (a) movement of nutrient ions to the absorbing root surface (b) roots reaching the area where nutrients available are important.

### 7.3.1 Nitrogenous Fertilizers

Nitrogen is of special importance in the formation of proteins, enzymes, hormones, vitamins, alkaloids, chlorophyll etc. It forms a constituent of every living cell in the plant. Plant growth is adversely affected due to deficiency of nitrogen. When nitrogen is present in sufficient quantities in the soil plants acquire a healthy green color, growth of the plant is fairly rapid and crop matures earlier resulting in good yields. Nitrogen promotes leaf, stem and other vegetative growth but retains small in root system. It improves succulence of leaf and quality and increases protein content of
food and fodder crops. It also governs the utilization of potassium, phosphorus and other elements.

A nitrogen starved plant is yellowish or light green in color and remains stunted. Such plant ripens prematurely and gives poor crop yields. An excess of nitrogen delays ripening by encouraging more vegetative growth. The leaves acquire a dark green color, become thick and leathery and in some cases crinkled. They also become soft and sappy. The plant becomes more liable to the attack of certain fungi and its resistance to disease is lowered. An excessive amount of nitrogen induces succulence.

These are classified into four groups on the basis of the chemical form. They are nitrate, ammonium nitrate, ammonium and amide fertilizers.

Sodium nitrate, calcium nitrate Ammonium sulphate, phosphate, chloride

Nitrate - Sodium nitrate, Calcium nitrate
Ammonium - Ammonium Sulphate, Phosphate Chloride.
Nitrate Ammonium - Ammonium nitrate, Calcium, Ammonium Nitrate, Ammonium sulphate.
Amide - Urea, Calcium cyan amide.

Nitrate fertilizers are obtained from synthetic ammonia. These are quickly dissociated in soil solution, releasing the nitrate iron for plant absorption. The nitrogen reaches the root zone quickly even the fertilizer is broadcasted in the soil. It also increases leaching. All these fertilizers are basic in their residual effect on the soils and their continued use reduces soil acidity. The sodium nitrate contains 16 percent nitrogen and traces of bOron and iodine. The 27 percent sodium has favorable influence on potassium economy.

Ammonium fertilizers are readily soluble in water and are available to the plant. But the plant utilizes less rapidly than nitrate nitrogen. These are resistant to loss by leaching. These are acidic in their residual effect on the soil. Ammonium sulphate contains 20-21 percent nitrogen. It is a crystalline salt, stable, soluble in water and stores well. It has 24 percent of sulphate.

Nitrate and ammonium fertilizers contain equal proportions (ammonium nitrate, ammonium sulphate nitrate) and in calcium ammonium nitrate 3/4 ammoniacal nitrogen and 1/4 nitrate nitrogen. These are readily soluble in
water. These are acidic in their residual effect. Calcium ammonium nitrate has 25 percent, ammonium sulphate nitrate has 26 percent nitrogen.

Amide fertilizers are available in as urea, calcium cyanamide and called organic fertilizers. These are readily soluble in water and decomposed by soil microbes. The urea is a crystal, white salt with 44-46 percent nitrogen. It absorbs moisture from the air (hygroscopic). It takes a few days after urea is applied to the soil thus likely to be wasted out from the soil if the soil is wet or water in it. It also produces acidity in the soil.

### 7.3.2 Phosphatic Fertilizers

Phosphorus is a constituent of sugar phosphates, nucleotides, nucleic acids, coenzymes and phospholipids. The process of anabolism and catabolism of carbohydrates proceed when organic compounds are esterized with phosphoric acid. Phosphorus in plant life is important inlaying down the primordial for the reproductive parts of the plants. It is also vital for cell division and development. It stimulates early root development and growth, thus helping to establish seedlings quickly. It gives rapid and vigorous start to plants, strengthens straw and decreases lodging tendency. It stimulates flowering and aids seed formation and quality. It also helps in fixing more atmospheric nitrogen in root nodules. Excess of phosphorus may caused deficiency particularly iron and zinc.

Most of the lands are deficient because it is not in available form to the plant. Application of this fertilizer retained in the soil and 20-40 percent is readily available to crops. In general 10-30 kg phosphorus is needed thus it is given 3-4 times. The nutrient content of this fertilizers are expressed in terms of percentages of phosphorus pentoxide (P$_2$O$_5$). Rock phosphate is the basis for this fertilizer.

These are classified into three groups depending on the form in which Orthophosphoric acid or Phosphoric acid is combined with calcium. They are

- **Water Soluble**
  - Super phosphates, ammonium phosphate
  - Citric acid soluble
  - Dicalcium Phosphate, basic slag.
  - Water or citrate insoluble
  - Rock phosphate, bone meal

Water soluble fertilizers are better for fast growing, short rooting plants. But readily available to plants. These can be used on neutral alkaline soils but not acidic soils. Super phosphate is most commonly used in India. It is
a brownish grey powder available in single, double and triple grades, which contain 16-20; 30-35; 45-50 percent super-phosphate respectively.

Citric acid soluble are suitable for acidic soils because with low pH. There are less chances of phosphates getting fixed as iron and aluminium phosphate.

Insoluble fertilizers are suited strongly acidic or organic soils, which require larger quantities of these fertilizers.

7.3.3 Potassium Fertilizers

Potassium is not a constituent of any organic compound. It is required as a cofactor for 40 or more enzymes. It controls movement of stomata and maintains electro neutrality of plant cells. Crop yield depends on potassium than nitrogen. Generally potassium is richly available in soils. If only nitrogen and phosphorus fertilizers are used the potash slowed reduced in the soil. This also affects absorption of other fertilizers in due course. There are some soils which are found to yield more when potassic fertilizers are applied. Sandy soils are known to respond to potash.

Potassium does not enter into the ‘composition of any of the important plant constituents. It occurs in a state of solution in the cell sap. It imparts increased vigor and disease resistance to plants. It regulates water conditions within the plant cell and water loss from the plant by maintaining the balance between anabolism respiration and transpiration. Thus reduces tendency to wilt. It is necessary in the formation and transfer of starches sugars, proteins and chlorophyll. It acts as a accelerator of enzyme action. It counteracts the injurious effects of excess nitrogen in plants and improves the quality of crops.

The deficiency results in yellowish leaf terminals and veins which later dry. The leaf margin, apex show curls and dry. The leaf shows small brownish spots. Fruits can be stored for long time.

These fertilizers are classified into two groups i.e. fertilizers having K in chloride form; K in non-chloride form.

Potassium chloride or muriate of potash is a coarse or fine salt most common and cheap. It has 60-96 percent potassium chloride and surely contains 60 percent potash, the whole of which is readily available. Though it is soluble in water, not SEPARATED from soil as it is absorbed by the soil particles.
Potassium sulphate contains 48-50 percent K20 in addition to 17.5 percent sulphur. It dissolves in water and immediately available to crop.

### 7.3.4 Secondary Nutrients

Calcium, magnesium and sulphur are supplied to the plants incidentally by the application of NPK and fertilizers are not manufactured to supply these nutrient.

Calcium is a constituent of cell wall and early root development and growth. It provides a base for neutralization of organic acids, commonly termed as poisons produced in the plant. It is essential to activate growing points. It influences the water economy of the plant, the proteins - carbohydrates ratio in fat metabolism. The calcium effects are antagonistic to potassium. Calcium improves intake of other plant nutrients specially nitrogen and trace elements by correcting soil pH.

Magnesium is a constituent of chlorophyll helps in maintaining dark green color in leaves. It is needed for production of carbohydrates, proteins, fats and vitamins and certain catalytic reactions. It acts as a carrier of phosphorus thus promotes of oils and fats. Helps in translocation of starches and regulates the uptake of other nutrients. Magnesium deficiency causes yellowing in between the veins only. The leaf is not erect. The leaf detaches very easily and may be shed by wind. Necrosis occurs in extreme cases only in margins.

<table>
<thead>
<tr>
<th>Deficiency Symptoms</th>
<th>Old Leaves</th>
<th>New Leaves</th>
<th>Old and new leaves</th>
<th>Terminal buds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N, P, K, Mg, Mo</td>
<td>S, Fe, Mn, Cu</td>
<td>Zn</td>
<td>Ca, B</td>
</tr>
<tr>
<td>Dead Spots</td>
<td>No Dead Spot</td>
<td>Green veins</td>
<td>Yellow veins</td>
<td></td>
</tr>
<tr>
<td>K, Mo</td>
<td>N, P, Mg</td>
<td>Fe, Mn</td>
<td>S, Cu</td>
<td></td>
</tr>
<tr>
<td>Green Veins</td>
<td>Yellow Veins</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mg</td>
<td>N</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 7.5 Identification of Deficiency Symptoms**
Sulphur helps in chlorophyll formation and encourages vegetative plant growth. It is an essential constituent of many proteins, enzymes and certain volatile compounds.

It promotes nodule formation on the roots of legumes, increases root growth. It also stimulates seed formation.

The deficiency of sulphur causes Yellow leaves which looks like nitrogen deficient. The leaf is small and the veins are pale than inter veinal portion. No dead spots appear. Plants do not lose lower or bottom leaves.

**Table 7.6**

Ca, Mg and S contents of different fertilizer materials

<table>
<thead>
<tr>
<th></th>
<th>Ca</th>
<th>Mg</th>
<th>S</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium Nitrate</td>
<td>19.4</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Gypsum</td>
<td>29.2</td>
<td>-</td>
<td>18.6</td>
<td>-</td>
</tr>
<tr>
<td>Rock phosphate</td>
<td>33.1</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Single super phosphate</td>
<td>19.5</td>
<td>-</td>
<td>12.5</td>
<td>-</td>
</tr>
<tr>
<td>Triple superphosphate</td>
<td>14.0</td>
<td>-</td>
<td>1.0</td>
<td>25.2 (P₂O₅)</td>
</tr>
<tr>
<td>Epsom salt</td>
<td>-</td>
<td>9.6</td>
<td>13.0</td>
<td>16.0</td>
</tr>
<tr>
<td>Potassium magnesia</td>
<td>-</td>
<td>11.1</td>
<td>22.3</td>
<td>43.5 (K₂O)</td>
</tr>
<tr>
<td>Potassium sulphate</td>
<td>-</td>
<td>17.5</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ammonium sulphate</td>
<td>-</td>
<td>-</td>
<td>24.2</td>
<td>31 (N)</td>
</tr>
<tr>
<td>Ammonium sulphate nitrate</td>
<td>-</td>
<td>-</td>
<td>12.1</td>
<td>48 (N)</td>
</tr>
<tr>
<td>Basic slag</td>
<td>-</td>
<td>-</td>
<td>3.0</td>
<td>21 (P₂O₅)</td>
</tr>
<tr>
<td>Copper sulphate</td>
<td>-</td>
<td>-</td>
<td>11.4</td>
<td>26 (Cu)</td>
</tr>
<tr>
<td>Ferrous ammonium sulphate</td>
<td>-</td>
<td>-</td>
<td>16.0</td>
<td>15.6 (N) 16(Fe)</td>
</tr>
<tr>
<td>Ferrous sulphur</td>
<td>-</td>
<td>-</td>
<td>18.8</td>
<td>21 (Fe)</td>
</tr>
<tr>
<td>Elemental sulphur</td>
<td>-</td>
<td>-</td>
<td>100.0</td>
<td>6</td>
</tr>
<tr>
<td>Urea-gypsum</td>
<td>4.6</td>
<td>-</td>
<td>0.6</td>
<td>36.8 (N)</td>
</tr>
<tr>
<td>Urea - sulphur</td>
<td>-</td>
<td>-</td>
<td>10.0</td>
<td>40 (N)</td>
</tr>
<tr>
<td>Zinc sulphate</td>
<td>-</td>
<td>-</td>
<td>17.8</td>
<td>36.4 (Zn)</td>
</tr>
</tbody>
</table>
In calcium deficiency the bud leaf becomes chlorotic while with green base. And one third chlorotic part becomes brittle. Death of terminal bud occurs in extreme cases.

### 7.3.5 Complex Fertilizers

Nowadays complex fertilizers are becoming more popular and can be applied as straight fertilizers. In contrast to straight fertilizers complex fertilizers are much more desirable for balanced treatment of the soil. These are available with all the three elements indifferent concentrations. These possess high content of plant nutrients more than 30kg per 100kg of fertilizer with uniform grain size. They supply nitrogen and phosphorus in an available form in one operation. Further these fertilizers are non-caking, non-hygrosopic thus safer for storage. The commonly available grades of complex fertilizers are 15:15:15; 19:19:19 (N:P:K). The grade of the fertilizer indicates the percentage of plant nutrient in the fertilizer.

### 7.3.6 Micronutrients

Out of 16 elements six nutrients are required in small quantities and referred as micronutrients. They are Fe, Mn, B, Zn, Cu and Mo.

#### 7.3.6.1 Iron

Plants of acidic soils absorb iron very easily. It helps for the formation of chlorophyll. It helps in absorption of other nutrients. It is a constituent of enzyme system which bring about oxidation - reduction reaction. It also regulates respiration, photosynthesis, reduction of nitrates and sulphates. It is essential for synthesis of proteins contained in the chloroplasts.

Deficiency of iron causes brown spots on the tender leaves and veins remain green. Chlorophyll looses its photosynthetic activity.

Application of the ferrous sulphate in the soil or plants reduces the deficiency. Mulberry requires 100 ppm of iron.

#### 7.3.6.2 Manganese

It is a constituent of several cation activated enzymes like decarboxylases, oxidases, hence, essential for the formation of chlorophyll, reduction of nitrates and for respiration. Its functions are closely associated with iron. It supports the movement of iron in the plant. It helps in protein synthesis in the chloroplasts. It also helps in counteracting the bad effect of poor aeration.

In manganese deficiency the principal veins and small veins are green.
The interveinal part is yellowish not tending towards whiteness. Dead spots also appear at a later stage. There is a checkered appearance to the leaf. Leaves become brittle and fall off. Basic soils are deficient in manganese. Manganese sulphate solution is sprayed on plants. One acre mulberry requires 500gr of manganese. Manganese sulphate contains 25 percent manganese.

7.3.6.3 Boran

Boron appears to be concerned with calcium metabolism both uptakes by roots and use in plants acts as a regulator of potassium calcium ratio in the plant. It also helps in absorption of nitrogen. It is a constituent of cell membrane and essential for cell division. It is necessary for translocation of sugars in plants. It helps the vascular system in root to give out branches to supply nodule bacteria with carbohydrate food so that bacteria may not become parasitic. It is effective on active salt absorption, hormone movement, flowering and fruiting processes, pollen germination, carbohydrate, nitrogen metabolism, metabolism of peptic substances, respiration, water metabolism and water relations in the plant.

Boron deficiency causes yellowing or chlorosis which starts from base to tip. The tip becomes much elongated into a whip like structure and becomes brownish or blackish brown. Death of the terminal bud occurs in extreme cases. Chlorosis occurs at the tips of the older leaves especially along the margins. Large, dark brown, elliptical spots appear subsequently and ultimately turn brown and dry up. Growth is reduced.

Fig 7.2 Deficiency Symptoms
Borax is a white compound containing 11 percent boron. Because of its high solubility in water, it is lost by leaching. Mulberry requires 20 ppm Boron for carbohydrate metabolism.

### 7.3.6.4 Zinc

Zinc is involved in cation activated enzymes. It regulates various reactions in the plant. It also influences for the formation of growth hormones. It is associated with water uptake and water relations in the plant.

Zinc is moderately mobile in plant and thus deficiency symptoms appear in middle leaves. The leaf becomes narrow and small. Lamina becomes chlorotic and veins remain green. Subsequently dead spots develop all over the leaf including veins, tips and margins. Plants appear bushy due to reduced inter-nodal elongation.

The quantity of zinc absorbed by the plant depends on type of land, organic manure of soil, calcium carbonate, pH, mineral concentration, environmental conditions, fertilizers, humidity. It is necessary to have 20 ppm Zinc in the soil for better growth of mulberry. Thus the plant can withstand extreme hot and cold. The zinc from mulberry is transmitted into silkworm and helps in their growth.

Zinc sulphate contains 36 percent zinc and can be applied to soil and plant. Soil application of the various zinc compounds is the suitable way of overcoming zinc deficiency.

#### Table 7.7

Micro nutrient contents in Organic Manures

<table>
<thead>
<tr>
<th>Manure</th>
<th>Zinc</th>
<th>Copper</th>
<th>Manganese</th>
<th>Iron</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic manure</td>
<td>120</td>
<td>62</td>
<td>410</td>
<td>-</td>
</tr>
<tr>
<td>Cow dung</td>
<td>210</td>
<td>61</td>
<td>150</td>
<td>-</td>
</tr>
<tr>
<td>Goat dung</td>
<td>2570</td>
<td>1925</td>
<td>6420</td>
<td>-</td>
</tr>
<tr>
<td>Poultry manure</td>
<td>70</td>
<td>82</td>
<td>191</td>
<td>1280</td>
</tr>
<tr>
<td>Rice straw</td>
<td>20</td>
<td>-</td>
<td>340</td>
<td>280</td>
</tr>
<tr>
<td>Pig manure</td>
<td>198</td>
<td>12</td>
<td>168</td>
<td>1600</td>
</tr>
</tbody>
</table>
7.3.6.5 Copper

Copper and zinc are involved in cation activated enzymes. It forms many compounds with amino acids and proteins in the plant. It acts as electron carrier in enzymes. It helps in utilization of iron in chlorophyll synthesis. In copper deficiency leaf is yellowish tending towards whiteness. In extreme deficiency

Chlorosis of veins occurs and leaf loses lustre. Leaf is unable to retain its turgidity and hence, wilting occurs. Leaf detaches due to water soaked conditions of the base of petiole. Deficiency leads to drying terminal leaves and leaf apex and become brittle. Copper helps the plant to absorb atmospheric nitrogen, soil nitrogen, and also from organic manure. Copper sulphate, contains 25.5 percent copper. Copper can be applied by spraying soluble salts on crops or applied to the soil.

Table 7.8

<table>
<thead>
<tr>
<th>Trace Elements</th>
<th>Concentration in ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe (Iron)</td>
<td>0.5-5.0</td>
</tr>
<tr>
<td>Mn (Manganese)</td>
<td>0.1-0.5</td>
</tr>
<tr>
<td>B (Boron)</td>
<td>0.1-1.0</td>
</tr>
<tr>
<td>Zn (Zinc)</td>
<td>0.02-2.0</td>
</tr>
<tr>
<td>Cu (Copper)</td>
<td>0.01-0.05</td>
</tr>
<tr>
<td>Mo (Molybdenum)</td>
<td>0.01-0.05</td>
</tr>
</tbody>
</table>

7.3.6.6 Molybdenum

It is required for assimilation of nitrates as well as for the fixation of atmospheric nitrogen. It acts in enzyme systems to bring about oxidation-reduction reactions. The nitrates are reduced to ammonia prior to amino acids and protein synthesis in the cells of the plant.

Molybdenum deficiency causes translucent spots of irregular shape in between the veins of leaves. These spots are light green, yellow or brown in color. The spots are impregnated with resinous gum which exudes from rear side of the leaf from the reddish brown spots. Ascorbic acid concentration is reduced leading to damage of chlorophyll. The activity of soil microorganisms and symbiotic microbes is reduced.
Ammonium molybdate (52 percent molybdenum), sodium molybdate (37 molybdenum) liquid can be sprayed on plants. It can also be mixed with complex fertilizers.

7.3.6.7. Chlorine

It is involved in reaction relating to oxygen evolution. From the point of view of soil fertility plants require one kg of chlorine for each four thousand kg dry matter they produce.

Its deficiency results in less chlorophyll thus drying of leaves finally.

7.4 Vermi Compost

Earthworms maintained as cultures in organic waste feed on the substrate.

The bed material thus undergoes physical and chemical breakdown in earthworm body. The undigested material is excreted as worm castings. These castings are physically, chemically biologically degraded organic material produced by earthworms which consists mainly of digested soil and organic matter. It is rich in all major and micronutrients, such as nitrogen, phosphorus, magnesium, zinc and calcium in simple forms, so that the plant root system can readily absorb them.

_Eudrilus eugeniae; Eisenia fetida-_and _Perionyx excavatus_ earthworms are used vermicompost preparation.

Vermi compost has many advantages over chemical fertilizers.

It restores microbial population which includes nitrogen fixers,

1. phosphate, solubilizers etc
2. Provides major and micro nutrients to the plants.
3. Improves soil texture and water holding capacity of the soil.
4. Provides good aeration to soil, thus improving root growth and proliferation of beneficial soil microorganisms.
5. Easy to handle and use.
6. Decreases the use of pesticides for controlling plant pathogens.
7. Improves structural stability of the soil, thus preventing soil erosion.
8. Provides an excellent effect on the overall growth of plants, makes leaves lush green and fresh.
9. Enhances the quality of the grains/fruits due to increased sugar contents etc.

10. Low cost easy to handle.

### 7.5 Application Methods and Schedules of Manures

Manures and fertilizers are applied to soil and directly to plant depending on its nature and plant requirements. The following are different methods.

a. **Broadcasting**: Application of fertilizer uniformly on the soil surface is called broadcasting. Generally it is carried on before sowing. The manure is placed as heaps and ploughed to mix with surface soil.

b. **Band placement**: Application of fertilizer in narrow bands beneath surface soil and by the side of crop rows. It is done before germination or along with sowing and at seedling stage.

c. **Point placement**: Placement of fertilizer near the plant root either in a hole or depression. It fastens the plant growth. However, little quantity of fertilizer is advisable.

d. **Foliar spray**: The fertilizer is applied as spray solution to the crop (plant).

   It is suitable for micronutrients.

e. **Root dipping**: The roots of seedlings are dipped in nutrient solution before transplanting.

The crop yields depend on type of crop, caliber of plants, inter cultivation, pest control, water resources, labour management and mainly nutrients available in the soil. Thus crop nutrient requirement are met by soil or fertilizer application. The farmer is conformed by soil tests. Generally soil nutrients are protected when manures and fertilizers are used equally. Thus soil testing is a prerequisite for any crop for recommending the dose and type of fertilizer.

### 7.5.1 Storing of Organic Manures

a. **Heap methods**: Manure is placed on the ground and protected with a small bund. Generally it is kept at a shadow place in the farm.

b. **Pit method**: A pit is made in the field, and bottom, sides are well protected to prevent the loss of fertilizer. A small ridge is made around the pit.
c. **Covered pit method**: It is similar to pit method but protected with a cover. This method is better than others.

### 7.5.2 Fertilizer Dose

The quantity of plant nutrient to be applied depends upon the crop, the dry matter produced, and the system of cultivation, the natural fertility of the soil and the availability or deficiency of the nutrient in the soil, whether the crop is irrigated or rain fed etc. The officials of agriculture, sericulture, soil testing, research labs recommend the amount of nutrients to be applied to the crop, time of application and number of doses etc.

Mulberry requires 300kg of nitrogen, 120kg of phosphorus and 120kg of potash per hectare of irrigated farm. Rain fed mulberry is recommended 100kg of nitrogen, 50kg of phosphorus, 50kg of potash per hectare.

<table>
<thead>
<tr>
<th>Schedule</th>
<th>Irrigated N-P-K</th>
<th>Irrigated N-P-K</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Recommended dose kg/ha per acre</td>
<td>300:120:120 120:48:48</td>
<td>100-50-50 40-20-20</td>
</tr>
<tr>
<td>b. To be applied in</td>
<td>Five split doses one dose after each crop</td>
<td>Two doses one dose after pruning and one after first harvest</td>
</tr>
<tr>
<td>c. Quantity of nutrients for each dose (per acre)</td>
<td>I dose 24-24-24 III dose 24-0-0 III dose 24-24-24 IV dose 24-0-2-0 V dose 24-0-0 Total 120-48-48</td>
<td>20-20-20 20-0-0 (After the rains when there is sufficient soil moisture) 40-20-20</td>
</tr>
<tr>
<td>d. Quantity and type of fertilizer to be applied per acre to provide the above nutrients.</td>
<td>I dose 160 kg 15-15-15 or 17-17-17 (complex) II dose Urea 53 kg or Ammonium sulphate 120 kg III dose Urea 160 kg 15-15-15 or 140 kg 17-17-17 (complex) IV dose Urea 53 kg or Ammonium sulphate 120 kg V dose Urea 53 kg or Ammonium sulphate 120 kg</td>
<td>133 kg 15-15-15 or 17-17-17 (complex) Urea 45 Kg or Ammonium sulphate 100 Kg</td>
</tr>
</tbody>
</table>
Summary

• The plant food elements in the soil are found both in the organic soil and mineral particles.

• Nitrogen, calcium, phosphorus, potassium are called primary plant elements in the soil.

• Application of nutrients to the soil to meet the plant needs is called manuring.

• There are many advantages which improve crop yields.

• Farmyard manure is the decomposed mixture of dung and urine of animals along with left-over/refuse which contains good amounts (N, 0.2% P2O5, 0.5% K2O) of plant nutrients.

• It is better to collect farm waste in specially made trenches for better decomposition.

• Compost is rotted organic matter made from farm waste.

• Night soil is human excreta is stored in poudrette system.

• Poultry manure contains higher amounts of nitrogen.

• Sheep peming is the better way to utilise urine and faecal matter.

• Gobar gas sludge, silkworm litter are other sources of nitrogen.

• Concentrated organic manures contain high amounts of NPK than organic manures. These are quick -acting manures.

• Oil cakes, blood meal, meat meal, fish meal, horn & hoof meal, bone meal are concentrated organic manures.

• Green manures add humus to soil, promote other activities like chemical action improve soil structure and water holding capacity, decrease soil erosion

• Plant needs 16 elements for their growth and completion of life cycle. For proper growth and development of crops the nutrients must be present in the soil in available form usable by plants.

• Inorganic manures are concentrated nature and contain NPK. There are straight and complex fertilizers.

• Fertilizer is called chemical or artificial manures.
• There are macro and micro nutrients. Macro nutrients are of primary and secondary nutrients.

• Nutrient availability depends on natural supply in the soil, soil pH, temperature, moisture, aeration, activity of microorganisms, application of artificial fertilizers, manures, green manures.

• NPK more important for plant metabolism, growth, maturity, and crop yield. Nitrate, ammonium, nitrate-ammonium, amide are different forms of nitrogen fertilizers.

• Phosphate fertilizers are superphosphates, ammonium phosphate, rock phosphate, bone meal.

• Potassium fertilizers are muriate of potash, potassium sulphate.

• Calcium, magnesium and sulphur are supplied to plants incidentally and are not manufactured.

• Complex fertilizers are combination of complex and straight fertilizers and more desirable for balanced treatment of the soil.

• Micro nutrients: Fe, Mn, B, Zn, Cu, Mo and chlorine are essential elements required in small quantities for various important activities in plant parts.

• Liming is adopted to reduce soil acidity. Gypsum, sulphur, iron sulphate are used reclaiming alkaline soils.

• Bio fertilizers help to fix atmospheric nitrogen (78 percent) and made available to plant in required form. Saprophytes, Rhizobium, Blue green algae, Azotobacter, Azospirillum, mycorrhiza are used for this purpose.

• Application schedules are more important for better farming. Crop yield depends on so many farming factors.

• There are broadcasting, band placement, point placement, foliar spray, root dipping methods of manure and fertilizer applications.

• Organic manures are stored in heap, pit or covered pit method not to loose nutrients.

• Fertilizer dose is decided by officers of concerned departments basing on the soil features and availability of nutrients and other factors.

• Manure and fertilizer schedules are different for irrigated and rain fed mulberry farms.
**Short Answer Type Question**

1. Expand FYM; NPK
2. Define compost, FYM
3. What is sewage and sludge?
4. What is green manuring?
5. What is urban compost?
6. Name some organic manure.
7. Name some concentrated organic manures.
8. What are the oil cakes used as manures?
9. What are complex fertilizers?
10. What do you mean by artificial fertilizers?
11. Name some macro and micro nutrients.
12. What are primary and secondary nutrients?
13. What are bio fertilizers?
14. What is vermi compost?
15. What are the methods of application of manures/fertilizers?
16. What are the methods of storing fertilizer?
17. What are the fertilizer requirements of mulberry?
18. Name some of the sources for micro nutrients.

**Essay Answer Type Question**

1. Write about farmyard manure.
2. Write about concentrated organic manures.
3. Write about green manures.
4. Write short notes on
   a. Compost 
   b. Poultry
5. Write about bulky organic manures.
6. Write short notes on
a. Sewage & Sludge   b. Oil cakes   c. Sheep & goat manure

7. Write short notes on

1. Write about macro nutrients.
2. Write about micro nutrients.
3. Detail about secondary nutrients.
4. Comment on complex fertilizers.
5. Write about bio fertilizers.
6. Write about vermi compost.
7. Write short notes on
   a. Storing of manures   b. Chlorine   c. Fertilizer dose

8. Write short notes on
   a. Fertilizer application methods   b. Application schedules

9. Write notes on micro nutrients?

**Numerical Questions**

- Identify the manures, bulky organic Manures, Concentrated organic Manure and Green Manure.
- Preparation of vermi compost.
- Preparing of compost
- Collect and preserved chemical fertilizers
- Identify the difference symptoms of Micro nutrients
- Adopt the balanced use of fertilizers in splitting doses.
Structure

8.1 Introduction
8.2 Harvesting Methods
8.3 Preservation of Leaf

Learning Objectives

After studying this chapter you will be able to

• Explain different types of leaf harvesting.
• Understand how to harvest and preserved the Mulberry leaves.
• Understand in chemical composition of exotic and indigenous mulberry.
• Explain effect of storage in the moisture content of Mulberry leaves and shoots.

8.1 Introduction

Silkworm feed on mulberry leaves. The success of silkworm rearing depends on the quality of leaf that is fed to silk worms.

Silkworms prefer fresh, healthy and succulent mulberry leaves. Silkworm during different stages prefers different nutritive quality of leaf.
Harvesting of mulberry leaves from the mulberry garden is of several types: (a) Leaf picking, (b) shoot-harvest, (c) branch cutting. Leave harvest depends on the type of rearing method adopted.

Young age silkworms are fed with the leaves of more water content for easy ingestion. Preferably the top leaves of the mulberry plant are harvested. Late age worms require mature leaves. Inferior quality of mulberry leaves damages the silkworm health condition and leads to failure of the crop.

The composition varies according to the ages of mulberry leaf. The nutrient quality of leaves varies from place to place. There are number of factors which influence on the composition of leaf like soil type, water, mulberry variety, season etc.

What is important is, not only production of quality nutrient mulberry leaf but also proper utilization of leaf.

The first leaf harvest should be done only 8 months after planting and the first pruning should be done after the first harvest of leaves to allow proper establishment of the plant.

8.2 Harvesting Methods

There are three methods of harvesting mulberry leaves.

1. Leaf picking
2. Branch cutting
3. Whole shoot harvest

8.2.1 Leaf Picking

In India most of the rears follow individual leaf picking. Individual leaf picking is a labour intensive; however, this is not a problem where there is no shortage of labour.

The leaves are harvested according to the age of silk worms. Tender leaves (top) are picked up, to feed the chawkie worms. As the stage of the silkworm advances mature (lower) leaves are fed to the worms.

The first leaf harvest begins about 10 weeks after bottom pruning and subsequent picking at an interval of 7-8 weeks. While harvesting the leaves, picking with petiole helps in retaining the moisture content for longer duration. Leaf picking without petiole is easier to harvest, and labour consuming practice.
After the leaves are harvested from the main stem, the terminal bud is allowed to develop. This will help in rapid development of lateral shoots. Otherwise growth remains dormant. The leaves of the secondary branches are picked up for second crop. Thus, 6-7 harvests in a year are possible after which the bushes are pruned almost to ground level.

**Advantages**

i. Wastage of leaf can be minimized.

ii. The main advantage of this method is that, leaves can be selected to suit the growth stage of larvae.

**Disadvantages**

i. It requires more labour.

ii. Leaves wither too quickly if not stored properly.

8.2.2 Branch cutting

The silk worms are fed with mulberry branches. In this method the entire branch is harvested and fed to silkworm after 3rd moult. This method is adopted in Kashmir and parts of West Bengal and Karnataka.
**Batchi System**

This system of feeding in Kashmir is called “Batchi” system and in Japan it is known as “Jossoiku”.

This is used with tree and middling plantations. This is also practiced in floor rearing and shoot rearing. There are many advantages by adopting this type of feeding.

a. Cost of labor can be minimized.

b. Easy to feed the silkworm.

c. In this type of feeding wastage of leaf can be minimized.

d. Bed cleaning process is easy and labor saving.

e. Quality of leaves can be maintained for a longer duration, since leaves are not detached from the branch, and the succulence will last longer.

f. Easy to disinfect the rearing equipment if branch feeding is adopted in shelf rearing or floor rearing, since much of the equipment like rearing dollars, feeding stand etc., is not required.

g. Easy to preserve and maintain quality.

h. Hygienic conditions can be maintained effectively in rearing house.

i. Maximum utilization of mulberry leaves by silkworm.

j. Saves labor in collection of leaf, disinfection of feeds, bed clearing and spacing.

**8.2.3 Whole Shoot Harvest**

The silk worm settled 4th moult could be fed with this type of harvested leaves. The mulberry branches are cut to the ground level and fed to the worms settled for 4th moult; so that a uniformity in maturity of leaf is observed. In this type of harvesting, shoots are harvested with an interval of 10 weeks and it may extend to another 2-3 weeks depending upon the availability of water and favorable climatic conditions. 4-5 harvests are possible in this type of harvesting method in a year. This method is suitable where the sprouting takes place throughout the year.

The branches are cut down to the ground level and the top leaves are fed to the worms settled for 4th moult. Thus, tapping helps uniform maturity of leaf over the plant. The effect of top clipping is that, the energy which
would go to the in formation of new leaves is redirected to the leaves left behind on the plant, which make them more uniformly mature.

**Time of Harvest**

Once the leaves are harvest from mulberry plant, the freshness goes on decreasing hour. In view of the active photosynthesis and transpiration during the day time, the leaves harvested late in the afternoon contain less water and more carbohydrates. The leaves harvested in the afternoon wither more rapidly.

Therefore, mulberry leaf should be harvested in the early morning, as the day passes the quality of leaves terms of moisture content comes down due to active transpiration. Hence, leaves are picked up during the morning or evening hours and preserved carefully.

Harvesting of mulberry under row system of cultivation compares the leaves grown on primary shoots, which are vigorous in growth and thin. The thinner leaves trend to dry faster. One of the reasons for thin leaves is close plantation. The alternate method to keep the quality of such leaves is feeding the worm by twig feeding or cutting the twigs along with leaves into larger bits.

One of the problem in this type is leaves grow faster on thinner branch; they have a tendency to got over-matured and turns yellow. During rainy season the moisture content will be more and increases the humidity in rearing bed.

When there is high humidity in rearing beds the outbreak of discusses like muscardine and grasserie results.

Hence, following care should be taken.

a. Avoid over feeding.

b. Providing proper ventilation in rearing rooms.

c. Harvesting leaves only when fully mature.

d. Proper bed cleaning.

e. Allow the bed to dry up fully.

In case of irrigated mulberry under pit system the leaves will be thicker and heavier, contain less moisture content during rainy seasons. One of the important to point to keep in view is, one irrigation should be given to the
garden before feeding the leaves to the worms after the 4th moult. So that, succulent leaves are available for the silkworms of last instars.

Leaf picking should be done during early hours of morning or evening. For chawki worms tender leaves i.e., 2nd and 3rd leaves below the growing bud are picked. In case of 3rd and 4th stage worms 3rd and 4th leaves are picked and as the stage of worms advances mature leaves can be fed.

**Transportation of Leaves**

As soon as the leaves are harvested from the mulberry garden, care should be taken in transportation.

1. Transportation of leaf should be always done in the morning hours.
2. Transportation of leaf should be always in baskets covered with a wet gummy cloth.
3. Transported leaves should not be kept as a heap, but they must be scattered and preserved in leaf chambers.

Generally, the leaves are harvested twice a day and are preserved for successive feedings. Therefore, as soon as the mulberry leaves are harvested it should be transported in basket covered with a wet gunny cloth. Transportation should be in the morning or late evening.

Construction of rearing house in the mulberry garden itself is recommended. This can avoid risk of transportation and withering of leaves and since the consumption of leaves changes in accordance with moisture content in leaves.

**8.3 Preservation of Leaf**

The leaves after harvesting should be transported carefully in the early morning or evening in gunny clothes. The leaves transported should be preserved in moist, cool and clear places in order to preserve their succulence. When the leaves are stored for a longer period, the nutritional changes take place in the leaves. The proteins are broken into amino acids and the carbohydrates are broken into simple sugars, leaves start withering. However, there is no net decrease of total nitrogen. The crude ash and fibre content are not affected during storage period. The major problem during storage is loss of water and deterioration of nutritive value by breakdown of carbohydrates and proteins.

To avoid deterioration of nutritive values in mulberry leaves and loss of water, the mulberry leaves should be stored at a R.H. of 90% or above
and temperature below 20°C. Preservation of chopped mulberry leaves for 1st and 2nd stage are tend to lose moisture content very much early.

To maintain the leaf quality, heaping up of leaves should be avoided otherwise it leads to fermentation. To avoid this leaves should be spread loosely. During summer the leaves withering starts very fast, hence frequent watering sprinklings should be done on the mulberry leaves.

There will be a problem if there are heavy rains and during winter. Dew or water droplets on the surface of leaf is common, feeding wet mulberry leaves to silkworms leads to attack of disease.

Precautions should be taken to spread the leaves under the fan and water droplets can be avoided. Leaves can be preserved in a wet chamber; wooden chamber covered with gunny cloth is used. The visible change withering is due to water loss. Water is lost by transpiration and hydrolysis reactions while some water is produced during respiration; the amount of loss is proportional to the period of storage.

During summer maintenance of leaf quality will be a problem. Water should be sprinkled frequently on the leaves stored. Usage of wet gunny cloth to spread over the leaves and sprinkling of water on the wet gunny cloth. Exposure to air currents should be avoided. Mulberry leaves stored in small size polythene bags of capacity 3-4 kg is convenient.

### Table 8.1

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Name</th>
<th>Type</th>
<th>Leaf Moisture</th>
<th>Total Minerals %</th>
<th>Crude Protein %</th>
<th>Non reducing Sugar</th>
<th>Non reducing Sugar %</th>
<th>Total Sugar</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Local</td>
<td>Tender</td>
<td>71.22</td>
<td>10.38</td>
<td>23.17</td>
<td>4.42</td>
<td>9.78</td>
<td>1420</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Medium</td>
<td>70.11</td>
<td>13.73</td>
<td>22.88</td>
<td>2.18</td>
<td>5.17</td>
<td>7.81</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mature</td>
<td>69.06</td>
<td>15.59</td>
<td>22.53</td>
<td>1.68</td>
<td>4.72</td>
<td>6.40</td>
</tr>
<tr>
<td>2.</td>
<td>Kanva-2</td>
<td>Tender</td>
<td>73.37</td>
<td>12.17</td>
<td>23.44</td>
<td>2.25</td>
<td>6.13</td>
<td>8.38</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Medium</td>
<td>70.13</td>
<td>17.10</td>
<td>20.92</td>
<td>2.23</td>
<td>5.48</td>
<td>7.71</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mature</td>
<td>69.82</td>
<td>18.73</td>
<td>18.27</td>
<td>2.06</td>
<td>3.96</td>
<td>6.02</td>
</tr>
</tbody>
</table>

Storing the leaves in heaps leads to fermentation; hence the leaves should be spread frequently. However, covering the mulberry heaps with a wet gunny cloth is traditionally following.

Leaf can be preserved in wooden leaf chamber conveniently with a size of 1.5m. x 1m x a.8m covered with wet gunny cloth. In some places
earthen pots are used for leaf preservation. The mulberry leaves are preserved inside the pot and the water is sprinkled around the pot frequently to keep cooling effect and to avoid drying of mulberry leaves.

![Fig. 8.2 Whole Shoot Harvest](image)

Leaf requirement will be more during 3rd stages onwards. Therefore, harvesting and preservation of leaves for at least one feed in advance is
practically done by the farmer. ‘During rainy season water droplets on leaf surface should be dried under fan or cleaned with a dry cloth. Feeding wet leaves to silkworm causes damage to the health of silkworm and are susceptible to disease attack. Care should be taken during the molts.

Covered with cloth

Pored pot

Leaves preserved in Atherial pots

Branch preserved in Gunny cloth

covered with gunny cloth

Leaves preserved in Bamboo basket

Fig 8.3
Preservation of leaves in wooden chambers covered with wet gunny cloth always convenient. In case of leaf to be stored in large quantity, then the leaf can be stored on a clean floor in a single layer over a gunny cloth. Proper air flow should be arranged and wet gunny cloth is recommended. Thus, leaf preservation should be carried out. The leaf can be preserved in pored pots and covered with wet cloth. Branches are preserved with wet gunny cloth. The single leaves are preserved in bamboo baskets covered with wet cloth.

**Summary**

- Silkworms are fed with mulberry leaves, the success of cocoon harvesting depends upon the quality of mulberry leaves.

- During its growth silkworm crosses four instars and the leaves at each instar with different nutritive values are preferred according to the age of silkworm. Young age worms are fed with the leaves of more water content, late age worms with matured leaves.

- Harvesting of mulberry leaves are of different types (i) leaf picking. (b) shoot harvest (c) branch cutting.

- Harvesting should be done in early morning or evening. The leaves harvested late in the afternoon contain less water and more of carbohydrates and it withers more rapidly.
• Care should be taken to (a) avoid over feeding (b) providing proper ventilation in rearing room (c) harvesting leaves only when fully mature (d) proper bed cleaning (e) allow the bed to dry up fully.

• For chawki worms tender leaves i.e., 2\textsuperscript{nd} and 3\textsuperscript{rd} leaves below the growing bud are picked. In case of 3\textsuperscript{rd} and 4\textsuperscript{th} stage worms 3\textsuperscript{rd} and 4\textsuperscript{th} leaves are picked and as the stage of worms advances mature leaves can be fed.

• After harvesting of leaves, care should be taken during transportation.

• Leaves should be transported during morning hours only.

• Leaves stored for a longer period results: the proteins are broken into amino acids, carbohydrates into simple sugars, leaves start withering.

• The mulberry leaves should be stored at a R.H. of 90\% and at temperature below 20°C.

• Leaves should be preserved in a leaf chamber made of wood with proper ventilation covered with gunny cloth.

• Sprinkling water frequently during summer, and during rainy season leaves should be dried under a fan or spread on clean floor.

Short Answer Type Questions

1. How do you maintain the quality of mulberry leaves during summer and rainy season?

2. How do you transport the mulberry leaves?

3. When do you harvest the mulberry leaves? What precautions do you take while harvesting of mulberry leaves?

4. What are the advantages in branch cutting?

5. How do you maintain the feeding value for young age silkworm and late age silkworm?

Long Answer Type Questions

1. Describe the methods of harvesting of mulberry leaves. What are the advantages and disadvantages in each method?

2. Explain the term ‘preservation of mulberry leaves.'
Numerical Questions

1. Single leaves are preserved in approved pots and covered wet cotton cloth.

2. Branches and covered with wet gunny cloth.

3. Leaves are preserved in bamboo baskets covered with wet cotton cloth.
Illustrations

I. Illustrated Working Process of New Mulberry Cultivation Technology

1. Nursery management for sapling

2.

1. Recommended mulberry variety, V-1

a. Branching type: Erect
b. Leaf: Large, entire, ovate, dark green, glossy and thick
c. Rooting ability: 94%
d. Leaf ability: 60-70 Mt/ha/yr
e. Suitable soil: Red loamy and black fertilizer and irrigation
2. Recommended mulberry variety, S-36

* Branching type: Spreading
* Leaf: Large, entire, cordite, plane green, smooth and glossy
* Rooting ability: 48%
* Leaf yield: 40-5MT/ha/yr
* Suitable soil: Red loamy soil
* Remark: suitable for chawki reading

3. Garden for cutting multiplication:

* Preparing separate garden for cutting multiplication
* Prevent mixing by uprooting undesirable varieties.
* Select 6 month old shoot of V-I and 8 months old shoots of S-36.
4. Selection of shoot:

* Harvest the shoots without damaging the bark.
* Remove thick lower portion and upper immature portion of the shoot.
* Keep the shoots under shade and sprinkle water.

5. Cutting by bill hook:

* Use sharp bill hook for preparation of cutting of 12-15 cm.
* Prepare the cutting by one stroke without damaging the bark.

6. Cutting by secateur

* Preferably use secateur for preparation of cutting of 12-15 Cm
* Secature makes clean cut without damaging the bark
7. Clean Section b Secateur

* Use of Secateurs gives clean cut without damaging the bark (L: Cutting by bill hook, R: Cutting by Secateur)

8. Ideal cutting

* Prepare cutting of 12-15 Cm length with 3-4 healthy buds.
* Select cutting of 10-15 mm. diameter.
* Preserve the cutting in wet gunny cloth under shade.

9. Protection from fungal diseases

* Dip the cutting in 0.1% Dithane M-45 solution for 30 minutes.
* Plant the cutting immediately after treatment.
10. Preparation of nursery bed

* Prepare nursery bed of 3 m (L) 1 m (W) 15cm (H).
* Apply sand uniform at the rate of 25 MT/ha and thoroughly mix with soil.
* Apply farm yard Manure at the rate of 20 MT/ha and mix thoroughly.

11. Irrigation channel and working road

* Prepare irrigation channel of 30 Cm wide and 15 Cm deep either of nursery bed.
12. Leveling of nursery bed

* Level the nursery bed before plantation.

13. Irrigation before plantation:

* Irrigate nursery beds one two days before planting the cutting.

14. Making for planting

* Mark each row at 20 cm apart with the help of rope and measuring.
15. Planting of cutting

* Plant cutting following 20*10 cm spacing.
* Insert cutting vertically exposing only one bud above soil.
* After planting, press soil around the cutting firmly.

16. Management of nursery-1

* Irrigate nursery beds once in 3-4 days.
* Remove weeds after 45 days of planting of cutting.
* Apply urea after weeding at the rate of 10 g/sq m. and mix well in the soil.

17. Management of nursery -2

* Spray 0.1% Bavistin for control of fungal diseases.
* Spray 0.2 % DDVP in case of pest attack.
18. Removal of weak shoots

* Remove weak shoots using and keep only one strong shoot per sapling.

19. Well developed saplings

* Irrigate nursery once in 4 days till transplantation of the sapling.
* Allow the saplings to grow in the nursery in the 4 months.
20. Uprooting of saplings

* Preserve saplings till plantation under shade covered with wet gunny cloth.

* Plant uprooted saplings in the main field as early as possible.

21. Defect of traditional sapling preparation

* No preparation of nursery bed.

* Dense plantation which results in low survival rate and weak saplings.

* Slant planting of cutting results in deformed saplings and difficult to plant.

* No application of fertilizer after planting.

* Poor irrigation.
II. Establishment of new mulberry garden

1. Land preparation

* Plough land Tractor 30-40 cm. deep.
* Allow weeds to dry for about two weeks.
* Spread FYM at the rate 20 MT/ha and mix thoroughly with soil by repeated ploughing.

2. Leveling of land

* Level land be Tractor or Bullock drawn leveler.
* Remove stones and weeds from the plot.
3. Collection of soil sample for testing

a  : Dig a pit of 30 cm*30cm*30cm

b  : scrape a thin layer of soil from all sides of the pit and collection about 250g soil sample.

c  : mix soil samples collected from 4-5 spots thoroughly and speared it non a newspaper.

d  : Drive the sample into 4 equal parts and reject two opposite parts.

Repeat the process and collect 250g sample in poly cover for testing.

4. Trench for sapling plantation

*  Prepare trench of 30cm deep along the row.
5. Plan for plantation

* Follow I – J system of spacing (90+50) cm. 60 cm
* This spacing accommodates 13, 888 plants/hectare.
* Leaf quality improves due to better sunlight and more space in between 2 paired rows.

6. Plantation of mulberry saplings

* Spread compost in the land cover with soil.
* Select good and healthy saplings of similar size
* Keep saplings in upright position in the trench.
* Cover the trench with soil.
7. **Arrange after planting**

* Plant the sapling in erect position and press the soil firmly around the sapling.

* Irrigate the plot immediately after the plantation.

8. **Pruning of saplings after Plantation**

* Prune the sapling as the height of 10cm above the round level using secateur within 3-4 days of plantation.

9. **Irrigation**

* Irrigate once in 2-3 days after plantation till the sapling are established.

* Subsequently irrigated once in 4 to 5 days in sandy loam, 7 to 8 days in black cotton and clayey soil.
10. Sprouting of saplings

* Allow 2-3 shoots to develop from each sapling taking care that the shoot should not touch each other.
* Apply first dose of fertilizer @ 50:50:50 kg NPK/ha after 2 months of plantation.

11. Well grown plants

* Do not harvest or cut the plant for six months after plantation.

12. First pruning after plantation

* Under irrigated conditions shoot grow up to 2-3 m in height within 6 months after plantation.
* It is the suitable time for first pruning.
13. Pruning by secateur

* Prune the plants as the height of 20 cm above the ground level.

14. Pruning by saw

* Use pruning saw for cutting of thick shoot.

* Maintain the crown height at 20 cm above the ground level.
15. How to make ideal mulberry stump

* Develop one main stump and three well developed shoots per plant.
* The crown height should be maintained at 20 cm above ground level.

16. Sprouting after first pruning of shoot

* Allow 3-4 shoots to develop from each main shoot.
* Remove excess spouts for better development of the shoots.
* Apply second dose of fertilizer @ 50 kg N/ha 20 days after pruning.

17. Well trained mulberry stumps and their growth

* Development of stump will be completed by 12-15 months after plantation.
* Maintain stump height at 20-25 cm above the ground level while harvesting.
III. For Young Age Silkworm Rearing

1. Planning for chawki leaf production (8 crops/year)

- Harvest shoot pruning and maintain stump height at 20-25 cm. above ground level.
- Use secateurs for pruning shoots.
- Maintain same height for all branches.

2. Shoots ready for first harvest
3. Suitable mulberry variety for chawki rearing: S-36

* High moisture Content in Chawki leaves (75-80%)
* Chawki leaf yield is 25-28 MT/ha/yr.
* Variety V-I can also be used for Chawki rearing.

4. Field suitable for chawki

* Select elevated flat land near the water source.
* Plant saplings under paried roe spacing of (90+150)*60cm.
5. Application of FYM after pruning

* Apply 40 MT of FYM/ha/yr in 8 equal split doses @ 5 MT/ha after each harvest of leaf/Shoot let.
* Mix FYM with soil thoroughly by Tractor/power Tiller/plough.

6. Application of chemical

* Apply fertilizer (N:P:K) after 15-20 days in case of shoot pruning or 10-150 days after top clipping.
* Apply N.P.K @ 260:140:140 kg/ha yr in 8 equal doses i.e., NPK @ 32.5:17.5:17.5 as kg/ha/crop after each leaf/shoot let harvest.
* Apply ammonium Sulphate as “N” source if soil P is above 7.0 or Urea as “N” source if soil P below 7.0
* Use single super phosphate for “P” and Muriate of potash for “K”.
* Evenly spread fertilizer in between paired row.
7. Irrigation in chawki field
* Irrigated once in 3-4 days with sufficient water.

8. Spraying “Seri boost” for quality mulberry leaf
* Spray 2.5ml seri boost/liter water at 25 and 32 days after pruning or 15 and 22 days top clipping.
* Seri boost increases nitrogen and micronutrients in leaves.

9. Removal of weak shoots
* Removal weak shoots 28 days after shoot harvest.
10. Chawki garden ready for harvest

Left : S-36 chawki at 35 days after pruning.

Right : V-1 chawki garden at 35 days after pruning.
10. Harvest by leaf picking

* Harvest by picking individual leaf during cooler hours.
* Collect in basket covered with wet gunny cloth.
* Carry the basket to the reading house as soon as the harvest is over.

11. Top clipping

* After the completion of chawki by leaf picking, cut the shoot tips 15 to 20 cm from the top.
12. Growth of shoot lets

* Remove weak shoot lets within 10-15 days after top clipping.
* Shoot lets will be ready for harvesting at 25 days after top clipping.

IV. For late age silkworm rearing

[Diagram of the rearing process]

One cycle of 70 days

- Pruning
- Growth (45-48 days)
- Brush 250-300 cfs for 1 acre garden in CRC
- Shifting of shawki worms: 6-7 days
- Harvest of shoots

Late age rearing using shoot
- Late age rearing starts: 15-16 days
2. Application of farm yard manure after Harvesting

* Apply 20 MT of FYM/ha/yr in 5 equal doses @ 4MT/ha within 3-4 days after pruning.

* Mix FYM with soil thoroughly by Tractor/power Tiller/Plough

3. Application of chemical fertilizers

* Apply N.P.K @ 350:140:140 kg/ha yr in 5 equal doses i.e., NPK @ 70:28:28 kg/ha/crop after each shoot let harvest.

* Use Ammonium Sulphate as “N” source if soil pH is above 7 or Urea “N” source if soil

* Use single super phosphate for “P” and Muriate of potash for “K”.

* Mix fertilizer thoroughly with the soil by ploughing/digging.

4. Preparation of irrigation channel

* Preparing irrigation channel within a period row manually or by bullock plough.
5. Irrigation

* Provide sufficient water once in 7-10 days.
* Fill furrow with water completely.

6. Drip irrigation

* Install micro tube or micro project drip system to save 40% water.
* Run the drip system for about 12 hours in the begging for soil.
* Situation. After wards run drip 1-2 hours every day.
7. Ploughing by Tractor

* Adjust tyres of cultivator suitably for tractor ploughing.
* Plough with tractor immediately after FYM application and after fertilizer application.

8. Ploughing by bullock and by power tiller

* Use bullock plough or power tiller at later stage of growth.

9. Implement for harvesting of shoots

* Use pruning saw to prune thick shoots and dead branches.
* Use secateurs to prune shoots and to remove weak branches.
10. Shoot Harvest

* Harvest shoots using secateurs for late age silk worm rearing.
* Maintain stump height at 20-25 cm from ground level.
* Collect pruned shoots immediately.

15. Transportation of shoots to rearing House

* Cover pruned shoots with wet gunny cloth avoid drying of leaf.
* Transport shoots immediately from the field rearing house.
V. Improvement of Existing Plantation

1. The standard improvement plan for existing mulberry garden methods are available.

1. Row removal and branch thinning in dense field like “kolar” system of mulberry garden.

2. Cutting at ground level for old plantation less than 15 years of age
   i) Dense field.
   ii) No proper stumps.
   iii) High cut or middle trained plants.

3. Uprooting and new plantation.
   i) More than 15 years old plants and more than 30% gap in the field.
   ii) Unsuitable variety.
   iii) Multi-trunk plants.

2. Removal of a Row

* In traditional row plantation with close spacing (60*15cm), reduce density by removing one row after every two rows.

* Removal of a row provides better light and air movement in plot. Which help to improve growth and quality.

* Due to improve growth, leaf yield does not reduce.
3. Remove weak branches
   * Remove weak branches
   * Keep only 8-10 strong branches
   * Leaf quality improves due to less density of branches

4. Spray “Seri boost” for quality mulberry leaf
   * Spray 2.5ml/It of “Seri boost” twice at 20-25 days and 30-35 days after pruning / harvesting
   * Application of “Seri boost” improves leaf quality with more nitrogen and micronutrients.
5. Removal of a row
* When mulberry bushes are more than 10-15 years old and yield starts decreasing due to many dead branches, prune the plants at ground level.
* Use only Pruning Saw to cut plants.
* After cutting plough the land.
* Irrigate plot sufficiently once in 3-4 days at initial stage and thereafter once in 7 days.

6. Training of plants after ground level cut (I Phase)
* Allow only 3-4 strong shoots to grow by removing weak shoots.
* Allow selected shoots to grow at least for 3 months.
* Prune shoots at the height of 10-15cm above ground level.
7. Training of plants after ground level cut (II Phase)

* Allow 3-4 branches to grow from each shoot.

* Prune branches by secateur keeping 3-4 buds during harvest.

* Maintain stump height at 20-25cm from ground level.

---

8. Improved old plants with good stumps

* Leaf quality improves due to more light and aeration in field.

* Development of new stumps improves leaf yield.

---

Appendix -1

Recommended Dose of Amendment for Reclamation of Soil

<table>
<thead>
<tr>
<th>pH range</th>
<th>Quantity (MT/ha) Lime</th>
<th>Gypsum</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.5</td>
<td>12.5</td>
<td>——</td>
</tr>
<tr>
<td>4.5</td>
<td>8.8</td>
<td>——</td>
</tr>
<tr>
<td>5.5</td>
<td>5.0</td>
<td>——</td>
</tr>
<tr>
<td>7.4-7.8</td>
<td>——</td>
<td>2.0</td>
</tr>
<tr>
<td>7.9-8.4</td>
<td>——</td>
<td>5.0</td>
</tr>
<tr>
<td>8.5-9.0</td>
<td>——</td>
<td>9.0</td>
</tr>
</tbody>
</table>

* Use urea as nitrogen source upto soil pH of 7.0 and Ammonium Sulphate as “N” source above soil pH of 7.0
Further, apply 40Mt of press mud per ha/year in 2-3 split doses if soil pH is above 8.0

Appendix-2

Characteristic Features of Mulberry Varieties, s-36 AND V-1

<table>
<thead>
<tr>
<th>Character</th>
<th>S-36</th>
<th>V-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parentage</td>
<td>Mutant from Ber.Local</td>
<td>S.30x Ber.C776</td>
</tr>
<tr>
<td>Branching type</td>
<td>Spreading</td>
<td>Erect</td>
</tr>
<tr>
<td>Ploidy</td>
<td>Diploid</td>
<td>Diploid</td>
</tr>
<tr>
<td>Avg.No of Shoots/plant</td>
<td>8-10</td>
<td>10-12</td>
</tr>
<tr>
<td>Leaf size and shape</td>
<td>Large, entire</td>
<td>Large, entire</td>
</tr>
<tr>
<td>Leaf surface</td>
<td>Smooth, glossy</td>
<td>Smooth, glossy</td>
</tr>
<tr>
<td>Leaf colour</td>
<td>Pale green</td>
<td>Dark Green</td>
</tr>
<tr>
<td>Rooting ability</td>
<td>48%</td>
<td>94%</td>
</tr>
<tr>
<td>Moisture content (%)</td>
<td>75.7</td>
<td>75.7</td>
</tr>
<tr>
<td>Crude Protein(%)</td>
<td>23.9</td>
<td>24.6</td>
</tr>
<tr>
<td>Total Sugar(%)</td>
<td>15.2</td>
<td>17.0</td>
</tr>
<tr>
<td>Reducing Sugar (%)</td>
<td>1.9</td>
<td>1.9</td>
</tr>
</tbody>
</table>

Appendix-3

Fertilizer Conversion Table

<table>
<thead>
<tr>
<th>N: P: K To Actual Fertilizers</th>
<th>Commercial fertilizer</th>
<th>Multiply by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen (N)</td>
<td>Ammonium sulphate/ Urea</td>
<td>5.002.17</td>
</tr>
<tr>
<td>Phosphate (P)</td>
<td>Single super Phosphate</td>
<td>6.25</td>
</tr>
<tr>
<td>Potash (K)</td>
<td>Muriate of potash</td>
<td>1.67</td>
</tr>
</tbody>
</table>
How to Use the Table

(i) \( N:P:K @ 32.5:17.5:17.5 \text{kg/ha/crop for chawki garden} \)

<table>
<thead>
<tr>
<th>Calculation for</th>
<th>Commercial fertilizer</th>
<th>Actual quantity of commercial fertilizer (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( N @32.5 \text{ kg} )</td>
<td>Ammonium Sulphate</td>
<td>(32.5 \times 5 = 162.5)</td>
</tr>
<tr>
<td></td>
<td>Urea</td>
<td>(32.5 \times 2.17 = 70.525)</td>
</tr>
<tr>
<td>( P @ 17.5 \text{ kg} )</td>
<td>Single super phosphate</td>
<td>(17.5 \times 6.25 = 109.375)</td>
</tr>
<tr>
<td>( K @ 17.5\text{kg'} )</td>
<td>Muriate of potash</td>
<td>(17.5 \times 1.67 = 29.225)</td>
</tr>
</tbody>
</table>

(ii) \( N:P:K @ 70:28:28 \text{kg/ha/crop for late age rearing} \)

<table>
<thead>
<tr>
<th>Calculation for</th>
<th>Commercial fertilizer</th>
<th>Actual quantity of commercial fertilizer (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( N @70 \text{ kg} )</td>
<td>Ammonium Sulphate Urea</td>
<td>(70 \times 5 = 350.0070 \times 2.17 = 151.900)</td>
</tr>
<tr>
<td>( P @ 28 \text{ kg} )</td>
<td>Single super phosphate</td>
<td>(28 \times 6.25 = 175.000)</td>
</tr>
<tr>
<td>( K @ 28\text{kg'} )</td>
<td>Muriate of potash</td>
<td>(28 \times 1.67 = 46.760)</td>
</tr>
</tbody>
</table>

Appendix -4

Preparation of Chemical Formulation for Spray

1. Preparation of “Seri boost” for spray
   a) Mix 2.5 ml seri boost in litre of water.
   b) Prepare 250 litres solution to spary in one area

   Spray schedule:
   i) First Spray : 25 days after pruning
   ii) Second spray : 7 days after first spray.

2. Preparation of DDVP Solution for pest control
   a) Dissolve 2.5 ml DDVP in 1 litre of 0.5% solution for control of Tukra
   b) Dissolve 1 ml DDVP in 1 litre of 0.5% soap solution for control of Leaf roller.
   c) Prepare 250 litres of solution to spray in one acre
3. Preparation of Fungicide solution to control fungal disease

   a. Dissolve 4g Bavistin (carbendazim 50% WP) in 1 litre of water.
   b. Dissolve 2.66g Kavach (Chlorothalonil 75% WP) in 1 litre of water
   c. Dissolve 1g Dithane M-45 in 1 litre of water for cutting treatment.
   d. Prepare 250 litres of solution to Spray in one acre.

Appendix - 6

Calendar of Cultural Operations for Chawki Mulberry Garden

<table>
<thead>
<tr>
<th>Days</th>
<th>Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Prune all the plants at 20-25 cm above the ground level</td>
</tr>
<tr>
<td>1-2</td>
<td>Maintain 10-12 shoots per plant. Remove dead portion of the shoots.</td>
</tr>
<tr>
<td>3-4</td>
<td>Apply FYM @ MT/ha/crop and mix well with soil by digging or ploughing.</td>
</tr>
<tr>
<td>5</td>
<td>Prepare ridge and furrows.</td>
</tr>
<tr>
<td>6</td>
<td>Irrigation</td>
</tr>
<tr>
<td>10</td>
<td>Irrigation</td>
</tr>
<tr>
<td>14</td>
<td>Apply chemical fertilizers NPK @ 32.5:17.5:17.5 kg/ha/crop. Ammonium Sulphate* for N, Single Phosphate for P and Muriate of Potash for K. Irrigate immediately after application</td>
</tr>
<tr>
<td>18</td>
<td>Irrigate at an interval for 4 days.</td>
</tr>
<tr>
<td>25</td>
<td>Spray “Seriboost” 2.5ml/lt of water.</td>
</tr>
<tr>
<td>28</td>
<td>Remove weak shoots.</td>
</tr>
<tr>
<td>32</td>
<td>Spray “Seriboost” 2.5ml/lt of water.</td>
</tr>
<tr>
<td>35</td>
<td>Brushing and leaf harvesting.</td>
</tr>
<tr>
<td>36-45</td>
<td>Harvest leaf by leaf picking and chawki rearing.</td>
</tr>
<tr>
<td>46-48</td>
<td>Top clipping, shoot thinning, application of FYM @ 5MT/ha/crop digging, ridge furrow making and irrigation.</td>
</tr>
<tr>
<td>48</td>
<td>Apply FYM @ MT/ha/crop and mix well with soil by digging or ploughing.</td>
</tr>
<tr>
<td>51</td>
<td>Apply chemical fertilizer NPK @ 32.5:17.5:17.5 kg/ha/crop. Ammonium Sulphate* for N, Single Phosphate for P and Muriate of Potash for K. Irrigate immediately after application</td>
</tr>
<tr>
<td>60</td>
<td>Spray “Seriboost” 2.5ml/lt of water.</td>
</tr>
<tr>
<td>67</td>
<td>Spray “Seriboost” 2.5ml/lt of water.</td>
</tr>
<tr>
<td>72</td>
<td>Brushing</td>
</tr>
<tr>
<td>73-78</td>
<td>Chawki rearing by using shootlets</td>
</tr>
</tbody>
</table>
APPENDIX -7

CALENDAR OF CULTURAL OPERATIONS FOR LATE AGE
MULBERRY GARDEN (ONE CROP)

<table>
<thead>
<tr>
<th>Days</th>
<th>Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Prune all the plants at 20-25cm above the ground level.</td>
</tr>
<tr>
<td>1-2</td>
<td>Maintain 10-12 shoots per plant. Remove dead portion of the shoots.</td>
</tr>
<tr>
<td>3-6</td>
<td>Apply FYM @ 4 MT/ha/crop and mix well with soil by digging or ploughing. Prepare ridge and furrows.</td>
</tr>
<tr>
<td>7</td>
<td>Irrigation.</td>
</tr>
<tr>
<td>15</td>
<td>Irrigation.</td>
</tr>
<tr>
<td>22</td>
<td>Apply chemical fertilizers NPK @ 70:28:28 kg NPK/ha/crop. (Ammonium Sulphate* for N, Single Super Phosphate for P and Muriate of Potash for K.) Irrigate immediately after application.</td>
</tr>
<tr>
<td>23</td>
<td>Irrigation (Spray 0.2% DDVP in case of insect attack).</td>
</tr>
<tr>
<td>25</td>
<td>Spray &quot;Seriboost&quot; at 2.5 ml/lt of water.</td>
</tr>
<tr>
<td>28</td>
<td>Remove weak shoots.</td>
</tr>
<tr>
<td>29</td>
<td>Irrigation.</td>
</tr>
<tr>
<td>30</td>
<td>Assessment of leaf availability for brushing.</td>
</tr>
<tr>
<td>32</td>
<td>Spray &quot;Seriboost&quot; at 2.5 ml/lt of water.</td>
</tr>
<tr>
<td>37</td>
<td>Irrigation.</td>
</tr>
<tr>
<td>40</td>
<td>Remove weak shoots.</td>
</tr>
<tr>
<td>44</td>
<td>Irrigation.</td>
</tr>
<tr>
<td>45</td>
<td>Brushing at CRC.</td>
</tr>
<tr>
<td>51</td>
<td>Irrigation.</td>
</tr>
<tr>
<td>53-54</td>
<td>Receiving chawki worms from CRC.</td>
</tr>
<tr>
<td>59</td>
<td>Irrigation.</td>
</tr>
<tr>
<td>66</td>
<td>Irrigation.</td>
</tr>
</tbody>
</table>

* If soil is acidic apply urea in place of ammonium sulphate as N source.
## APPENDIX - 8

### STANDARD MULBERRY CULTIVATION SYSTEM FOR BIVOLTINE

<table>
<thead>
<tr>
<th></th>
<th>Selection of variety</th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Young age rearing S-36, V-1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Late age rearing V-1</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Check the soil pH</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5.5 to 7.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Optimum: 6.2 to 6.8)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Planting material</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sapling plantation is preferred. Prepare a good nursery, plant cuttings of 6-9 months of age, 12-15 cm of length with 3 active buds in 20x10 cm spacing in nursery. Use 4 months old saplings for plantation. <strong>Cuttings from 6-9 months old shoots can also be planted directly.</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Land preparation</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Use tractor plough first followed by cultivator or country plough. Apply 20 MT FYM/ha at the time of land preparation and mix well.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Method of Plantation</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Paired row plantation with (90-150) cm x 60 cm spacing is ideal. Plant the saplings in erect position. Prune the saplings at 10 cm above ground level within 3-4 days of plantation. In case of cutting plantation, only one cutting per pit should be planted keeping only one bud above the soil.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Initial fertilizer application</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Apply fertilizer (N:P:K) @ 50:50:50 kg/ha after 2 months of plantation.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Initial training and pruning</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Saplings: Prune the plants during first harvest at 20 cm above ground level. Cuttings: Prune the plants at a height of 10 cm above ground level 6 months after plantation. Keep 3 strong shoots and during next harvest, prune at the height of 20 cm from ground level.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Maintenance of established garden</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FYM: 20 MT/ha/year in 5 splits for lateage silkworm. Apply FYM at 40MT/ha/yr in 8 splits for chawki garden. Fertilizer: N:P:K @ 350:140:140 kg/ha/year in 5 equal splits for late age and N:P:K @ 260:140:140 kg/ha/year in 8 equal splits for chawki. If soil is acidic, use urea as source of Nitrogen or otherwise use Ammonium sulphate. Avoid using complex fertilizer.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Irrigation</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>For young age: Once in 3-4 days. For late age: Once in a week. If possible use sprinkler. Drip system can also be used in case of water shortage.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td></td>
</tr>
</tbody>
</table>
| **10** | **Spraying of Seriboost**  
Spray Seriboost (M/s.Sericare, Bangalore) @ 2.5 ml/Lt two times at 25 days after pruning and the second spray after 7 days of first spray. |
| **11** | **Shoot thinning**  
Remove weak shoots after 30 days of pruning. |
| **12** | **Harvesting**  
Use only secateur and pruning saw for shoot harvest. |
| **13** | **Yield**  
For late age rearing (MT/ha/year): V-1-60-70 |
| **Improvement of existing garden** | **Row system:** Removal of a row after a pair and shoot thinning.  
**Other:** Shoot thinning of weak branches. Keep 8-10 well grown shoots. Very old plants (15 years or more): Prune at ground level. Allow the sprouts to grow. Keep 3-4 strong shoots and remove others. Prune at the height of 10-15 cm. Next pruning at another 15 cm height with a total height of 20-25 cm. Always maintain around 10 number of shoots per plant. |
Appendix-9

Training and Establishment of Plant

* Plant good saplings and within 3-4 days of planting cut the saplings at 10 cm above ground level using secateur.

* Allow only 3-4 good branches to develop.

* After 6 months of plantation, cut the plants at 20 cm above ground level using secateur.

* Maintain stump height at 25 cm above ground level.

Appendix-10

Preparation of Compost Using Sericultural Wastes

* From 1.00 acre mulberry garden about 5-8 MT organic waste is available in one year.
* Prepare trench/cement tank of 4.5 m(L) X 1.5m (B) X 1.0m(D) in shaded area.

* Fill the trench with sericultural waste, ash and other organic wastes layer by layer. After every one foot waste, a layer of cow dung slurry should be spread.

* Spread 20kg Rock Phosphate and 100-150 g lime.

* Fill the trench up to one foot above ground level and then cover the trench with mud and cow dung.

* Provide shade to the trench to protect from direct sunlight and rain.

* Within 3-4 months, compost will be ready and from one trench of above said dimension about 4MT compost can be obtained.

* By utilizing the sericultural waste for the preparation of compost, the premises of rearing house can be kept clean and hygiene.

---

**Appendix-11**

**Green Manuring in Mulberry**

* Leguminous crops of short duration with high bio-mass production capacity like Sunhemp (Crotalaria juncea) Dhaincha (Sesbania aculata) can be used in mulberry for green manuring to enrich soil fertility.
* Use Sunhemp for red soils and Dhaincha for black soils.
* About 8 kg seeds are required for one acre.
* After pruning and intercultural operations broadcast the green manure seeds in the field.
* Incorporate the green manure crop into the soil about 45 days after sowing of seeds or before flowering.
References

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11. Bulletins on Sericulture, CSB, Bangalore.
14. Illustrated working process of new mulberry technology by Dr. K. Kawakami and Dr. Yanagawa.