IVC Course Code : 112

SERICULTURE (Seri)

First Year

(w.e.f. 2018-19)

Intermediate Vocational Course

Paper I : **Mulburry Cultivation**

Paper II : **Silkworm Rearing Reuirements & Managements**

Paper III : **Silkworm Rearing Technology**

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ANNUAL SCHEME OF INSTRUCTION AND EXAMINATION FOR

1st YEAR SERICULTURE COURSE

Part – A		Theory		Practicals		Total	
		Periods	Marks	Periods	Marks	Periods	Marks
1	General Foundation Course	150	50	-	-	150	50
2	English	150	50	-	-	150	50
Part - B							
3	Paper – I Mulberry Cultivation	135	50	135	50	270	100
4	Paper – II Silkworm Rearing Requirements and Management	135	50	135	50	270	100
5	Paper – III Silkworm Rearing Technology	135	50	135	50	270	100
6	OJT	-		365	100	365	100
	Total			770	250	1475	500

On the Job Training (After completion of 1st year exams practical training in Organization

EVALUATION OF ON THE JOB TRAINING:

The “On the Job Training” shall carry 100 marks for each year and pass marks is 50. During on the job training the candidate shall put in a minimum of 90 % of attendance.

The evaluation shall be done in the last week of January.

Marks allotted for evaluation:

S.No	Name of the activity	Max. Marks allotted for each activity
1	Attendance and punctuality	30
2	Familiarity with technical terms	05
3	Familiarity with tools and material	05
4	Manual skills	05
5	Application of knowledge	10
6	Problem solving skills	10
7	Comprehension and observation	10
8	Human relations	05
9	Ability to communicate	10
10	Maintenance of dairy	10
	Total	100

NOTE: The On the Job Training mentioned is tentative. The spirit of On the Job training is to be maintained. The colleges are at liberty to conduct on the job training according to their local feasibility of institutions & industries. They may conduct the entire on the job training periods of I year and (450) II year either by conducting classes in morning session and send the students for OJT in afternoon session or two days in week or weekly or monthly or by any mode which is feasible for both the college and the institution. However, the total assigned periods for on the job training should be completed. The institutions are at liberty to conduct On the Job training during summer also, however there will not be any financial commitment to the department.

SERICULTURE

Paper - I

MULBURRY CULTIVATION

INDEX

UNIT 1

History of Sericulture

1.1 Introduction

Sericulture is an Agro - based Industry, the term which demotes Production of Silk through silkworm rearing. 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 activities can provided employment to people either directly or indirectly. Sericulture improves frequent returns throughout the year with relatively less expenditure common inputs.

1.2 History

Today there are more than 25 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 secrete 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. Later during war period soldiers carried mulberry cuttings and silkworm eggs secretly to their countries and then it spreads to rest of world.

1.2.1 History of sericulture in India

According to western historians, mulberry cultivation 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 Christian 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 silkworm rearing and silk reeling techniques. In

1771, the Chinese Silk was introduced with the object to produce quality of Cocoons. Between 1717 and 1775 the Haitian methods of rearing was introduced by East India. The attempt to replace indigenous breeds of Silkworm 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, Europe and middle East. 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 Producers 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 553AD, 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.

1.2.2 Central Silk Board(CSB)

In1948 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 in1949.

1.3 Silk Road

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 Milelong road moving through Bagdad, Tashkent, Damascus and Istanbul. The 6000 miles long lengthy road is historically called the "Silk Road".

1.3 Silk production

Today there are more than 29 countries in the world practicing sericulture and producing different kinds of silk. India stands second next to China in raw silk production. There is a domestic demand for raw silk in India for >25000 MT but the annual production is up to 19000 MT only, for remaining we are depending on China. Targeted production is 30000 MT by year 2020. In terms of export India earning > 900 Cr. of foreign exchange.

SILK & SILK-GOODS EXPORT EARNINGS [₹. in Crore

Itemwise Export	NOVEMBER		APRIL TO NOVEMBER	
	2017(P)	2016	2017-18 (P)	2016-17
	₹.	₹.	₹.	₹.
Raw Silk	NE	0.08	0.003	0.24
Silk Yarn	0.41	0.38	3.23	4.07
Fabrics, Madeups	28.79	27.67	231.09	286.50
Readymade Garments	53.17	114.89	638.57	564.83
Silk Carpet	1.27	0.31	7.25	26.32
Silk Wastes	8.63	8.48	60.58	70.56
TOTAL	92.27	151.81	940.72	952.52

Source: CSB Annual report

1.5. Employment opportunities and self employment schemes

As said above sericulture is an Agro-based industry, where mulberry is a fieldbased agriculture activity, silkworm 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 the following enterprise.

(i) Mulberry cultivations and silk worm rearing

(ii) Chawki Rearing Centre (CRCs)

(iii) Silk reeling unit of 6, 12, 24, 48 basins

(iv) Twisting units of 60,120,240,360,720 hank capacity.

(v) silk dying,

(vi) silk trading

(vii) Silk weaving units

(viii) silk export etc.

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 courses are open to employees of state sericulture department, NGO's, Private organizations, unemployed youth / reelers / weavers. Universities also offering academic and research-oriented courses. 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-based industry.
- 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 is sericulture?

Essay Questions

1. Write about history of sericulture?

UNIT 2

Morphology and Taxonomy of Mulberry

Learning Objectives

In this chapter the student will be able to

- Know he distribution of Mulberry 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 its preservation

2.1Introduction

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 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. 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

2.2. Distribution of Mulberry

varieties to suit the eco climatic conditions of particular area.

Mulberry plant is distributed all over the world. It can be grown in temperate and tropical regions. Mulberry cultivation is adapted traditionally by 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 30^0 north latitude and contains polyvoltine silk worms. India is the only country to produce all the four types of silk viz., Mulberry, Tassar, Eri and Muga and 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 mulberry varieties are different types. According to Mukerjee (1899), *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* are the varities of *M. alba*.

Based 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 Berhampur variety.

Morus alba

Cultivated in Punjab, North, and West Himalayas ascending to 3500 m. The trees grow to height of 10-15m.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 and then southern plateau in Karnataka and Tamilnadu ascending upto1500M. There are several varieties 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 9mt. In temperate Himalayas from Kuma on Hills westward, up to an attitude of 3000m.

Morus lavigata

This species is distributed in tropical regions from Indus valley to Assam

wild cultivated ascending to 1500M.

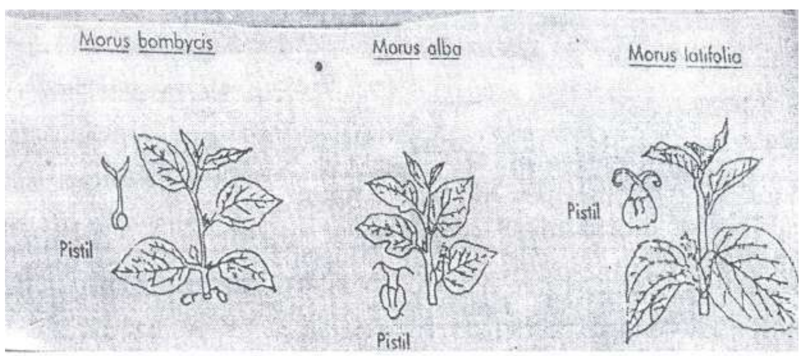


Fig. 2.1 Mulberry Varieties

Morphological Characters of some Mulberry species

2.3 Mulberry varieties

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

Selection of Mulberry variety for a particular region plays an important role. Based on the existing environment, soil, climatic conditions, season and region specific an improved, superior mulberry varieties 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

1. Kanva-2
2. Berhampur local
3. Mysore local
4. Sujanpura-1
5. S1
6. Sujanpura-2
7. MR-2(Mildew resistant variety)
8. Sujan pur-3
9. Assambola
10. Sujanpur-4
11. Anantha (high yielding variety recommended for south India)
12. Sujanpur-5
13. AR-12(alkaline resistant variety)
14. Dhar local
15. Kotia
16. Botatul
17. C763
18. S146
19. Tsaritul
20. S799
21. S-13 (Drought resistant)
22. Maulanium
23. S-36 (Suitable for chawki rearing)
24. S-54
25. V1
26. G2 & G4 (Better than V1)

Fig.2.2 Kanva-2 (M5)

These are the two most important varieties. Mysore local (Fig 2.3) grows in rain fed conditions and is drought resistant, can with stand dry climatic fluctuations. M5 is superior variety (Fig 2.6). The leaves are better quality with more protein content under irrigated conditions, the leaf yield per hectare is 3 -35 MT.

Fig. 2.3 Mysore local with lobed Leaves

Fig. 2.4 S-34

Fig. 2.5 V1

Fig. 2.3 S-13

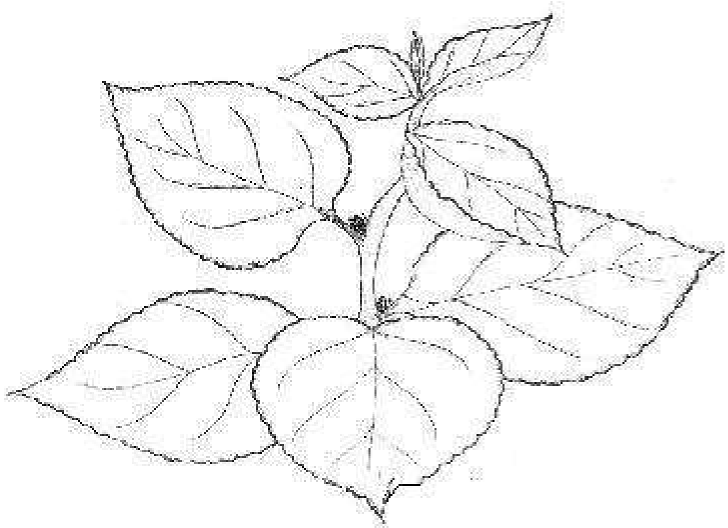


Fig. 2.6 M5

Fig. 2.7 S-36

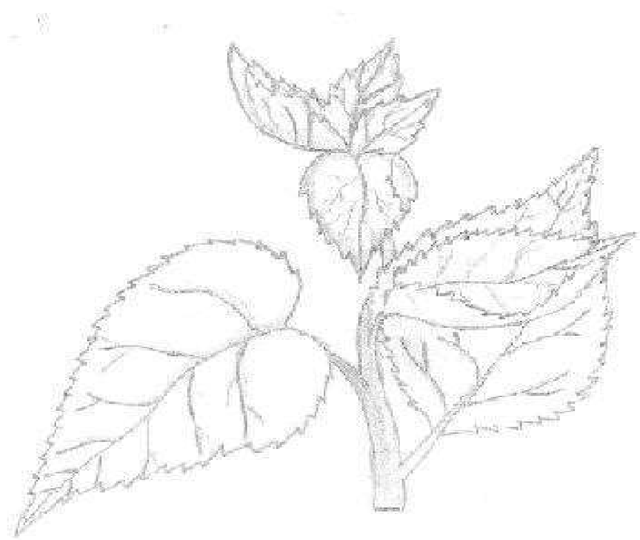


Fig. 2.8 S-41

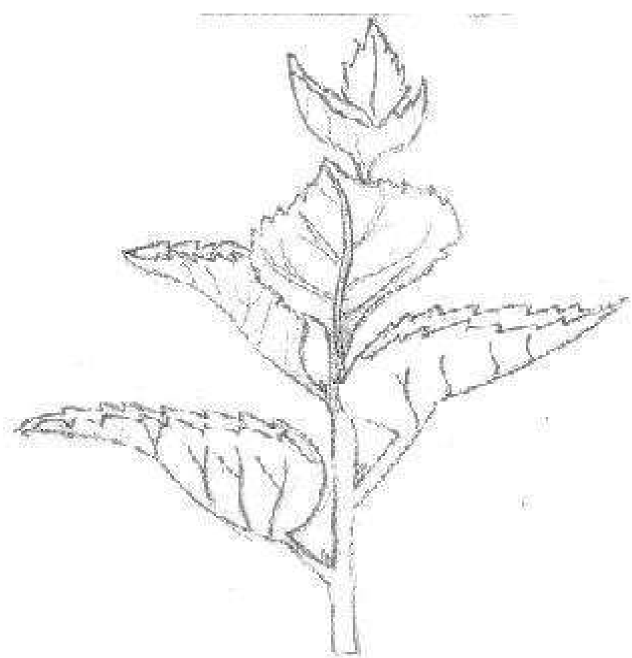


Fig. 2.9 S-30

S-30: It grows in all types of soils. The leaves are bigger in size and more proteinaceous. Leaf yield per hectare / year is 35- 38 MT

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

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, leaf yield per hectare / year is 37-47 MT.

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

V1: This is the new variety evolved by CSR &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 / hectare /year is 60 MT and it depends on the type of soil, climate, availability of water, and mulberry variety. Leaf yield in different popular Mulberry varieties (MT/Ha/Yea

Table: Leaf yield of different popular mulberry varieties (MT/Ha/Year)

Variety	Local	K2	S54	S36	VI	S13	S34
Irrigated	25	35	42	40	60	44	45
Rain fed	11	13	*NR*	*NR*	*NR*	16	17

NR: Not recommended

G4: This is an improved mulberry variety and improved high yielding mulberry variety with a leaf yield of about 65 MT/hectare/ year under assured irrigated conditions and with recommended package of practices. The variety is a hybrid of ***M. multicaulis*** and ***S30*** developed at Central Sericulture Research and Training Institute (CSR&T|), Mysore. G4 performs on-par with V1 a popular mulberry variety in south India. The foliage of G4 is of excellent quality and ideally suitable for rearing late age silkworms. The variety is characterized by erect branches, thick dark-green leaves and short inter-nodal distance. It is a diploid variety (2n=28) with high rooting ability (> 90%) which leads to high survival rate in the nursery

Fig 2.10 G4 Mulberry variety

Source: CSR&TI, Mysuru

2.4 Systematic position of mulberry

Kingdom	:	Plant kingdom
Division	:	Phanerogamae
Sub division	:	Angiospermae
Class	:	Di-cotyledons
Sub clan	:	Monochlamydae
Series	:	Uni sexuales
Family	:	Moraceae
Genus	:	*Morus*
Species	:	*alba*

The following characteristics are found in mulberry plant.

Characteristics of Angiosperms

The angiosperms or flowering plants are all plants with flowers and fruit and are the most recently evolved of all plant groups. They are also the most diverse and abundant plants throughout the globe and have come to dominate many of the world's forests. Angiosperms can be defined as vascular plants with seeds, fruit, and flowers for reproduction. Angiosperms have a unique relationship with animals that other plants do not. Many angiosperm species rely on interaction between animals and their flowers for reproduction.

As insects, birds or other animals move from one flower to another feeding on nectar, they commonly distribute pollen from flower to flower as they go which leads to plants being pollinated and seeds to be produced. Animals can also play a role in the dispersal of many angiosperm species by feeding on the fruit of the plant and carrying the seeds to new locations.

Subsequent to pollination of the stigma and fertilization of ovules, maturation of capillary tissues occurs with the ovules developing in to seeds and the ovary wall into the fist.

Class: Dicotyledons

The name Dicotyledons 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 hallow 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

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 occupations mostly in the tropical and subtropical in the layers and Assam. The best-known example of Mulberry (Morus Species)

In Moraceae 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.

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 Phanerogami sub division Angiosperm, dicotyledons, family Moracae.

Mulberry belongs to the genus Morus there are 35 spices of Morus. 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 is based on "Genome constituent", an external character like leaves, flowers and fruits etc.

Ledebour (1846-1851) classified *Morus alba* and *M.nigra* on the basis of papillae and pubescence on the stigma. While Brandis (1996) classified the mulberry species into two sections by the length of its style. Hoho divided 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 mulberry varieties is also much confused. Based on the principles of classification adopted by Hotta (1954), Gururajan (1960), they devided the mulberry varieties into three spices i.e ***Morus alba***, (Mysore, Tamilnadu, A.P) ***M.bombysis*** (Berhampur varieties) ***M.latifolia***(Kashmir, U.P).

2.5 Morphology and Taxonomy of Mulberry

Morphology of Mulberry

Mulberry belongs to the family Moraceae and genus morus. 35spices 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, it grows up to the height of 22-25 mts. With girth about 8 mts. The bust attains a hight of 1.5-1.8 mts which would be ideal for leaf harvest.

Stem

The colour of the bark varies from green, grey to pink or brown. Colour varies and depends upon the species, climate and origin. Mysore local K_2, Berhampur 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 turn brown at 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 and shapes are different according to the Mulberry varieties. 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 and the 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 maybe 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 contain scystolith, 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 flowers are unisexual (plants monoecious or dioecious) actinomorphic and hypogynous to epigynous. The parianth consists of usually four persistent, free of united petals which are valuate or imbricate in bud. The perianth sometimes absent as in female flowers of some species. 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, 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 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.

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. 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 ($5^{o}C$) 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 roots transport and pressure water and nutrients. In general, depending upon the soil condition the roots penetrate to a depth ranging from10 Cm to50 Cm.

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.

Sometimes *M-alba, M-serrata* provide wood which is particularly valuable in the manufacture of sports goods.

High lights in Review:

- Mulberry is a hard 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.

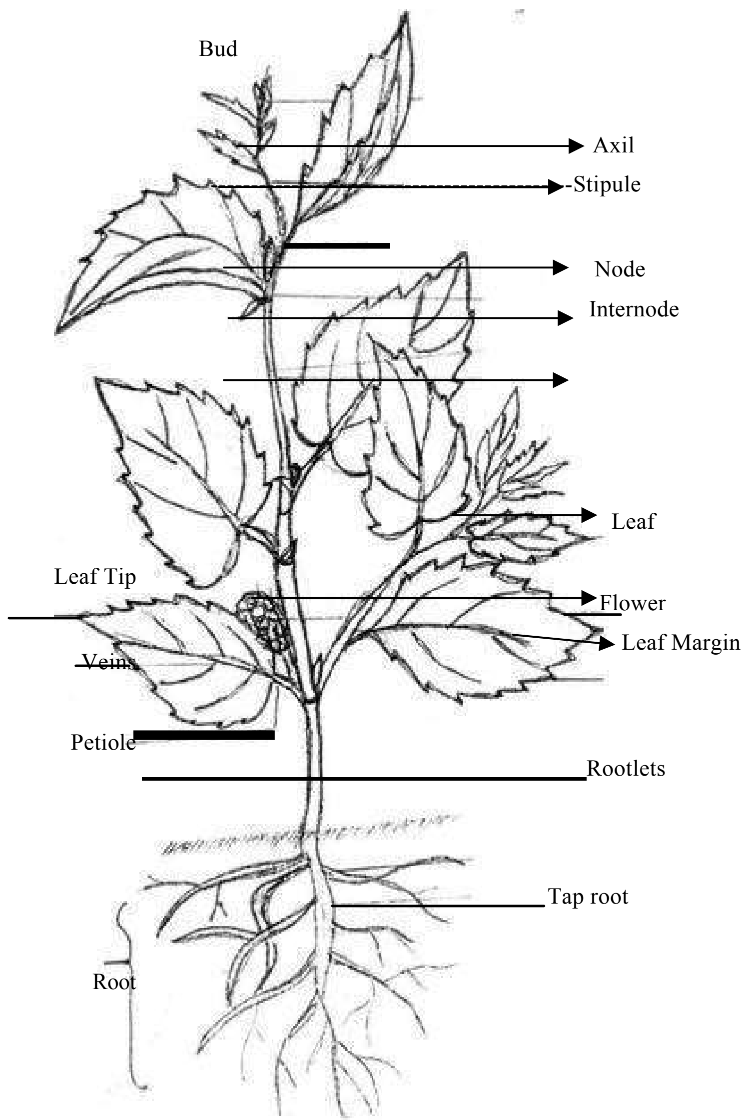


Fig. 2.11 Mulberry Plant

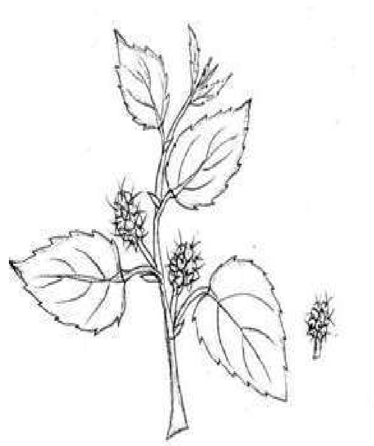
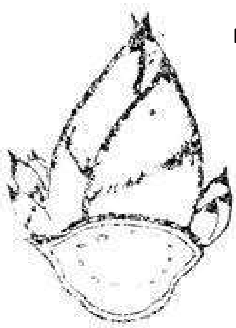


Fig. 2.12 Female Catkin **Fig. 2.13 Male Catkin**



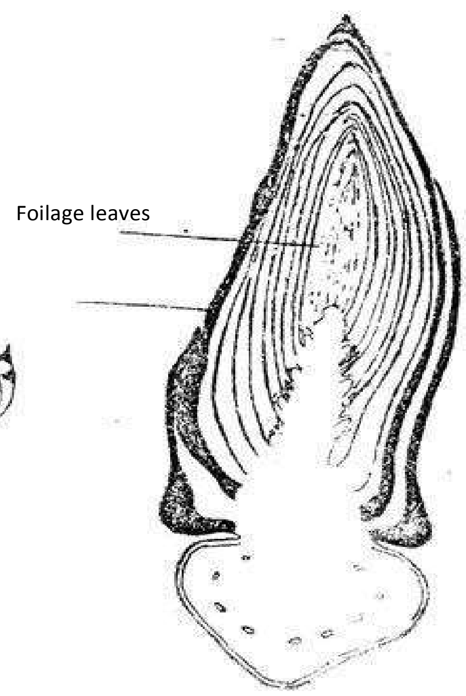


Fig.2.14 Bud **Fig. 2.15 LS of Bud**

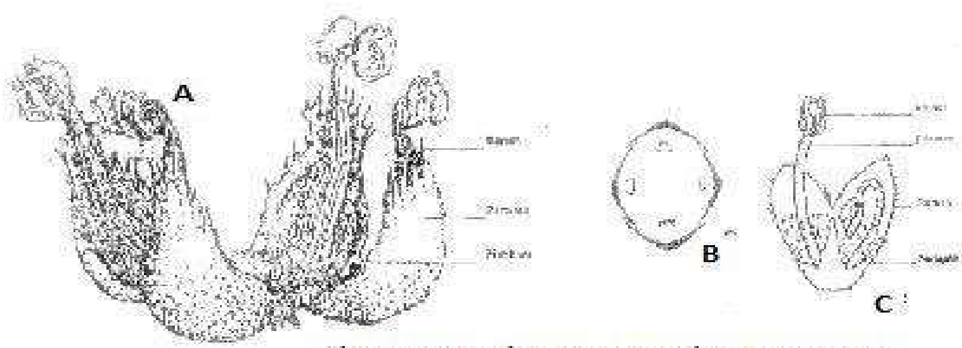


Fig. 2.16 A) Male Flower B) Floral Diagram C) L.S. of Male Bud

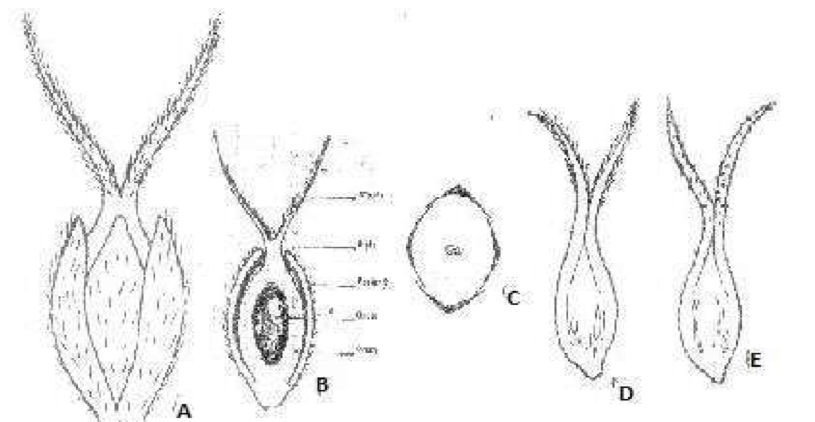


Fig. 2.17 A) Female Flower B)L.S. C)Floral diagram D) Stigma Pubscent E) Stigma Papillose

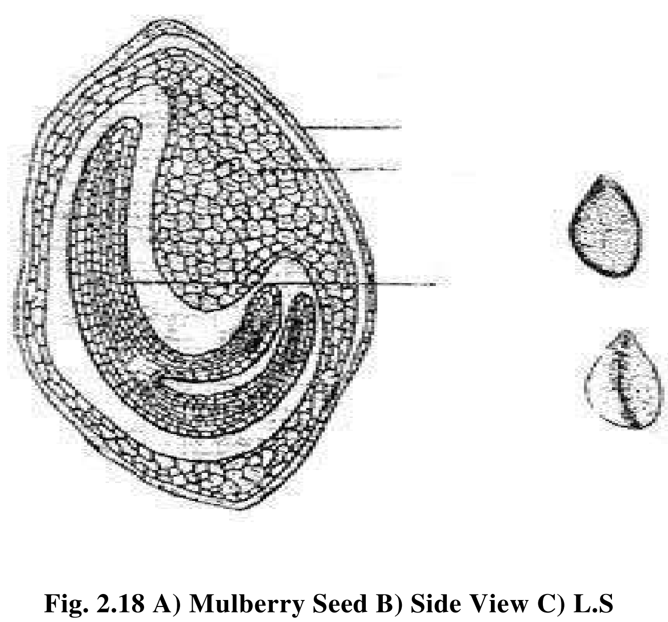


Fig. 2.18 A) Mulberry Seed B) Side View C) L.S

Fig. 2.19 A-C M*orus alba* 1. A. Flowering branch with male inflorescences x 2/3 B. Female Inflorescences x 2/3;
C. Distillate flower x 6 2/3.

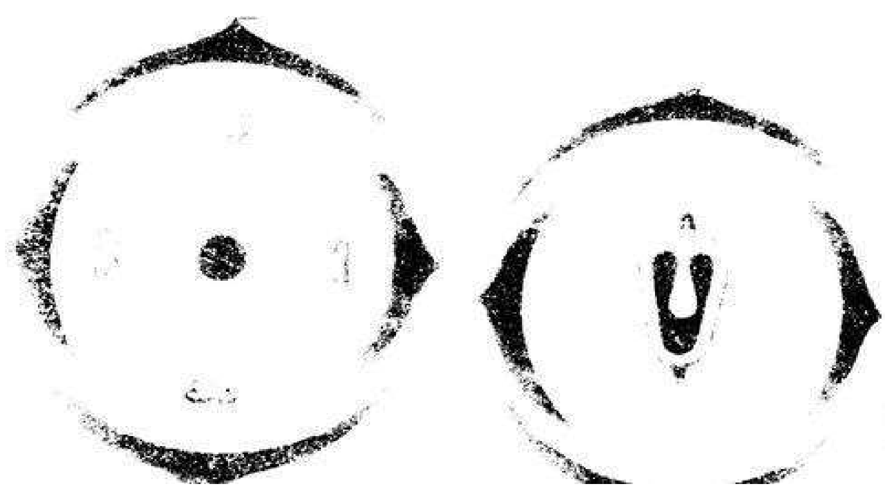


Fig. 2.20 floral diagrams

Summary

- Mulberry be belong to family Moraceae and it includes 1400 species mostly distributed in tropical sub -tropical zones.
- Mulberry grow as shrubs, herbs and small tress. Mostly in tropical and sub-tropical zones.
- Leaves and alternate, rarely opposite, simple, forming cup over the young leaves. Those leaves are primary food for silkworm.
- Inflorescence is catkin. Male and female flowers are separated.
- Male flower has four perianth leaves
- Stamens are arranged opposite to perianth leaves.
- Female flower, after fertilization it becomes thick and juicy.
- Multiple fruit pollination by wind. Fruits are drupe and fleshy. Seeds are endospermic and Non- Endospermic with curved embryo.
- Embryo has primary axis and two cotyledons.
- Root has tap-root, lateral roots and root hairs.
- Mulberry will grow in any type of climatic condition but light is more important for photosynthesis 2.0-10.2 hrs/day light is optimum.
- 24°-28° C temperature and average rainfall is 50mm. /once in 10days and atmospheric humidity is 65-80% is necessary for sufficient growth of the plant.
- Tree stem portion is best wood for making sports goods like cricket bats etc.,

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.
6. What is the planting season suitable for Mulberry?
7. Write notes on G4 variety.

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 detailed description of Moraceae Family with example of Morus Plant.
7. 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.,

UNIT 3

Non-Mulberry Food Plants

Learning Objectives

After studying this chapter, you will be able to

1. Understand about non-mulberry silk worm food plants and their economic importance.

Introduction

The "wild silks" comprise Tasar, Muga, Eri, Anaphe, Fagara, Sinew, Mussel,Spider and Coan. The non-mulberry silk production is mainly by *Antherea mylita*, *A.pernyi, A.yamamai* (Tasar); *A. assamensis*,(muga) and *philosamia ricini,* (Eri). Although these wild silk worms 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.

3.2 Tasar, Eri and Muga Food Plants

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 ½^0 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. 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 (Fig 3.1)*

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

3.1. Terminalia arjuna

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.cochinchinsis, S.thoreli, S.obtusa, S.hypochlora* and rich base for nature grown tasar cocoons. In India, it is widespread expect*., S.robusta. S.robusta* is abundant throughout the world and provides a 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-Himalyan 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.glauca, Q.semicarpifolia and Q.himalayan* where as the flora of the eastern belt are *Q.serrata, Q.semiserrata and Q.deblbata*. The foliage of the western flora matures early except that of *Q.himalayana*,and the foliage of the eastern flora are generally matures late (Jolly et al., 1974).

3.2.2 MUGA

Som (*Machilus bombycina*) and Soalu (*Litsaea Polyantha*) Fig 3.2 &3.4, 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.

Fig 3.2. SOALU

Fig 3.3.SOM

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.

Fig: 3.4 Ricinus communnis (Castor)

Tapioca: Scientifically called *Manihot esculenta* is an alternate food plant to eri silkworm. This species is native to the northeast region of Brazil, but its use spread throughout South America. The plant was carried by Portuguese and Spanish explorers to most of the West Indies Africa and Asia. In India Kerala, Tamilnadu, Orissa and some North Eastern states it is cultivated for its roots which are rich in starch and consumed and made in to different recipes. It is a tropical, perennial shrub that is less commonly cultivated in temperate climate zones. Cassava thrives better in poor soils than many other food plants. Although tapioca is a staple food for millions of people in tropical countries, it is devoid of nutrition and low in food energy. In developed countries, it is used as a thickening agent in various manufactured foods.

Fig: 3.5 TOPIOCA

Secondary food plants

Systematic position:

The following taxonomic position of some secondary food plants of non-mulberry silkworms are as follows.

Tasar

TropicalTasar

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. *Melostoma labthricum*, L. (Vern.Phutki);
11. *Zizyphus jujube*,Mill.(Vern.Ber);
12. *Z.rugosa,*Lam.(Vern.Bhand)
13. *Z.xylopyra.* Willd. (Vern.Kathber) Z.mauritiana, Lam. (Vern. Indian Ber orHevi);

Order: Lamiales; Family: Verbeaceae

14. *Tectona grandis*,L.f.(Vern.Sagwan)

Order: Malves; Family: Moraceae

15. *Ficus religiosa*. L. (Vern.Pipal);
16. *F.retusa*, L.(VernChilkan);
17. *F.tseila,*Roxb.

Order : Parietales: Family: Dipterocarpaceae

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

Order: Gentianles; Family: Apocynaceae

19. *Carissa carandus*,L.(Vern.Karumcha);

Order: Gerniales; Family: Meliaceae

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

Order: Rubiales; Family: Rubiaceae

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

Order: Sapindales; Fam: Sapindaceae

22. *Dodanaeae viscose,* (L.) Jacq. (Vern.Aliar);

Order: Sapindales; Family: Sapotaceae

23. *Madhuca indica*,Gmel.(Vern.Mahuxa)

Order: Roasales; Family: Laguminousae; Sub-fam: Caesalpinadae

24. *Hardwickia binata*,Roxb.(Vern. Anjan);
25. *Baluhinia vareiegat*, L.(VernKachar).

TEMPERATE TASAR (OAK BASED) Order: Fagales; Family:Fagaceae

26. *Qurecus aegilops* L. (Valoniaoak);
27. *Q.borealis, Michx.*f.(American Redoak);
28. *Q. Canariensis,Willd.* (Canary Islandoak);
29. *Q.castaneaefolia,* C.A. Mey (Chestnut leavedoak);
30. *Q.cerris* L.(Turkeyoak);
31. *Q.cocoinea*, Munchh.(Scarletoak);
32. *Q. frainetto,* Ten. (Hungarianoak);
33. *Q.hispanica*, Lam, var. lucombena (Sweet), Rehd. (Eng. Lucombe oak)
34. *Q.ilex,* L. (Evergreenoak);
35. *Q. libani,* (Lebanonoak);
36. *Q. lustianuca*, Lam. (Lusitanianoak);
37. *Q. Palustris*, Munchh. (Pinoak);
38. *Q. Petraea*,(Mattuschka) Libel. (Sessileoak);

39. *Q. reticulatam* Humb and Bonpl. (Net- leafoak);
40. *Q.robur,* L. (Englishoak);
41. *Q.Suber,* L. (Cork oak);
42. *Q. semicarpofolia*, Smith (Vern.Kharshu);
43. *Q. glauca*,Thunb (Vern.Inai);
44. *Q.acutissima*;
45. *Q.cripula;*
46. *Q.mongolica;*
47. *Q.mysrinaefolia;*
48. *Q.dentata;*

Order: Salicales; Family:Saliaceae.

49. *Salix viminalis (Eng.Willow).*

MUGA

50. *Litasea cirata,Blume*,(Vern.Sittimber);
51. *L.salicifolia,* Roxb. (Vern.Digloti);
52. *Actiinodopline sps.*
53. *Cinnamonumsps*.

Order : Magnoliales;Family: Magnoliaceae

54. *Michielia champaca*,Linn

Ordre: Rhammales;Family:Rhammaceae

55. *Zizphus jujube*, Mill. (Vern.Ber)

Order: Geraniales: Family: Rutaceae

56. *Zanthoxylum rhesta* DC (Vern.Bajramani);

Order:Lamiales: Family: Verbenaceae

57. *Gmelina arborea,* Roxb. (Vern.Gambari);

Order: Celatrales: Family: Celatraceae

58. *Celastrus monosperma*,L. (VernBhuroti)

ERI

Order: Euphorbiales; Family:Euphorbiaceae

59. *Manihot utilissima,* Pohl. (Vern. Simul-Alu)

60. *Jatropa curas*, Linn(Vern. Bhotera); 63.*Sapium Sps*. P.Br.

Order: Geraniales: Family:Simarubaceae

61. Alianthus excels, Roxb. (Vern.Maharukh);

Orderily: Geraniales: Fam: Rutaceae

62. Evodia flaxiniflora. Hook, F. (Vern.Pyam);

Order: Geraniales: Family: Caricaceae

63. Carica Papaya, L. (Vern.Papita);

Order: Gentianales: Family: Apocynaceae

64. Plumera rubra, L. form acutifolia (PoirP (Vern.Gulancha)

Short Answer Type Questions

1.Write classification of Non-Mulberry Plants.

2.Mention Secondary Food Plants of Tasar, Eri, Muga Silkworms.

3.Economic importance of Som Plant.

Long Answer Type Questions

1. Write in detailed about the Non-Mulberry Food Plants of Tasar, Eri, and Muga Silkworms.

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UNIT 4

Soils and Preparation of Land

Structure

Learning objectives

After learning 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 the soils in India and A.P.

Introduction

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.

In plant growth system soil is formed by various components such as minerals, organic matter, water and air, microorganism soil particles and soil. These features depend on the parental material. There are three main kinds of rocks. (1) 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. (2) Sedimentation rocks are formed from igneous rocks by consolidation of fragmentary rock material and decomposition products. (3) 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.

4.1 Types of soils and Properties

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:**-**

(i) Dubba Soils

(ii) Chalka Soils

(iii) Sandy – Clay soils

(iv) Deep Clay Soils

(v) More deep Sandy Clay soils

2. Black soils
3. Gangetic soils
4. Genetic soils
5. Saline and Alkaline soils
6. Costal sandy soils

4.1.1 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 P^H 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 costal 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.

4.1.2 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 states of India.

These soils are very heavy with 65-80 percent of 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 aluminum 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.

4.1.3 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 from5.0 to 6.8. In Telangana districts of A.P. red and black soils are predominant while the former are sandy loam.

4.1.4 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 Kamataka, 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 Andhrapradesh.

4.1.5 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 unfavorable 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 produce low yields and even crop failures in extreme conditions.

4.1.5.1 Reclamation

- The salts accumulated at the root zone should be leached below the root zone into the deep layers.
- 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.
- Alkalinity can be reduced to some extent by application of green manures and deep ploughing.
- Sulphur is given at the rate of 2 to 4 tons per hectare for reclaiming alkali soils with calcium carbonate.

4.1.6 Acid Soils

The acidic content is more in these soils with pH less 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 become low with increasing acidity. Soil microbiological activities are adversely affected as the acidity increases.

4.1.6.1 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 should not be used.

4.1.7 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.

4.1.8 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.

4.1.9 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 anaerobic 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.

4.2 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 bring 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.

4.2.1 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.

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

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.

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.

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.

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

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 (macropores) 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.

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.

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.

Soil structure

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

4.2.2 Chemical properties

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, Sulpur, 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.

4.3 Suitable Soils for Mulberry

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.

4.3.2. 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.

4.3.3 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.

4.3.4 Sandy-Clay Soils

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

4.3.5 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 ArakuValley.

4.3.6 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.

4.3.7 Laterite, Lateritic Soils

These red soils are formed in warm humidity, climatic zones with good rainfall and drainage features, found in Medak, Rangareddy, Nellore, Prakasham, 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. 8 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.

4.4 Soil P^H and Reclamation

In a P^H range of 6.5 – 7.5, the availability of nutrients to the plants will be optimal, and hence the input given to the garden will be utilized by the plants to the maximum extent resulting in a proportional increase in plant growth and leaf quality

Abnormal increase or decrease of soil P^H due to any reason will hamper the plant growth and leaf quality despite proper inputs. In such cases, soil reclamation is quite essential. Abnormal soils may be reclamated as follows.

Soil P^H	**Reclamation**
7.4 – 7.8	0.8 MT Gypsum / acre
7.9 – 8.4	**2.0** MT Gypsum / acre
8.5 – 9.0	**3.6** MT Gypsum / acre
9.1 & above	**5.7** MT Gypsum / acre

3.5	**5.0** MT Lime / acre
4.5	**3.6** MT Lime / acre
5.5	**2.0** MT Lime / acre

**Application of Gypsum @ 3.2 MT/ acre/ year can be followed as a general recommendation to reduce soil pH

**Application of press mud @16 MT/acre in 2 splits reduces soil pH from 8.5 to 7.6. It is also a rich source of "Phosphorous"

- **Determination of soil P^H:**

10g of sewed soil +25ml of distilled water→shake well for 30 minutes→ read with P^H meter.

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 Malda, Mushirabad and Birbhum mulberry is grown in Indo- Gangetic alluvium soils. These soils are generally grey, light brown to brown in colour. Sandy loam to 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, under lain with “murram” 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.

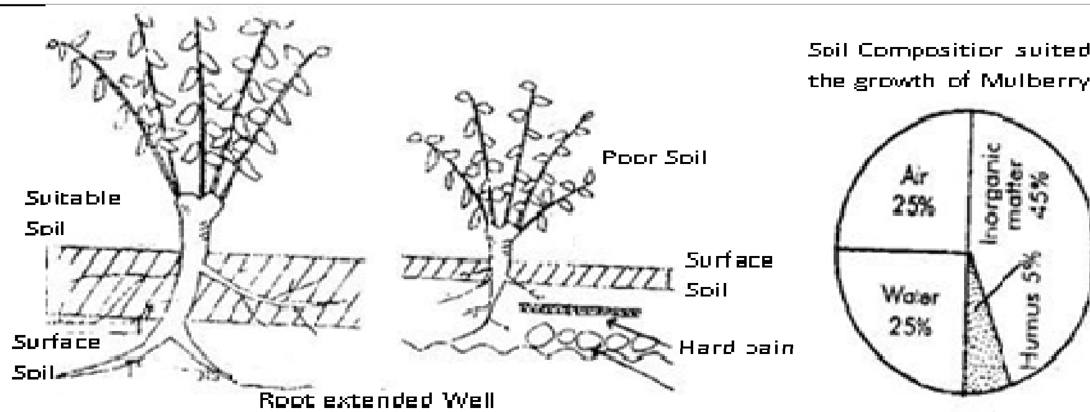


Fig. 4.1Suitable and Unsuitable Soils

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. Lf the slope is below15° 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 chilly fields, or chards influence the quality of mulberry leaf. Smoke and liquid effluents from factories are harmful and affect the leaf quality. Nicotine, chilly fields often contaminate the mulberry leaves which is poisonous to the

4.6 Layout of Plantation

silkworms. Hence great care should be adopted while spraying such chemicals. It is advisable to establish mulberry garden at least about 100 Mtrs 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 wind ward side serve as wind-breaks.

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 in to 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 stop 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 for soil amendments to correct the soil. Testing also help to know, which soil is suitable for which crop based 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 therefore, 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 them selves.

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.

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.

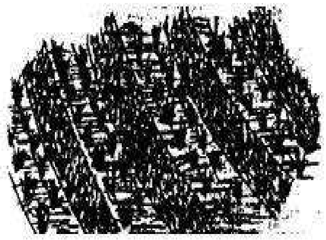
Mulberry is an arboreous, deep rooted plant. Thus, a thorough preparation of the soil with a deep ploughing or digging is a prerequisite for mulberry, whether it is rain fed or irrigated crop. After cessation of monsoon rains, the land is dug deep with a crowbar in case of small areas. Otherwise ploughing with a heavy mold broad 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 farmyard manure is applied at the rate of 10 tones/ha in pit sand 20 tones/ ha in trenches before planting under rainfed 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**

The face of the terrace must be protected with Posture process

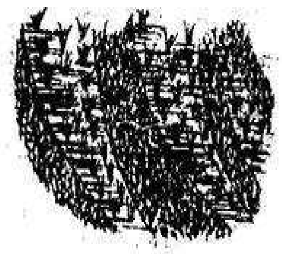
a.Bench Terrace



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

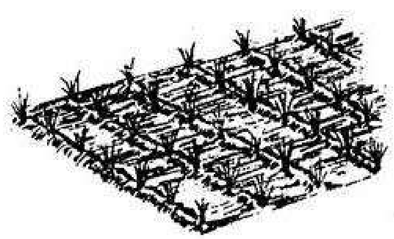
The face of the terrace must be protected with contour Posture process

a. b.Contour Terrace

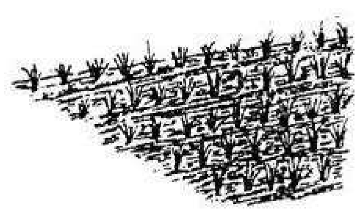


The terrace width is varied depending on the original contour

2. **Sloped Mulberry Field** Mulberry bushes are planted along the contour lines

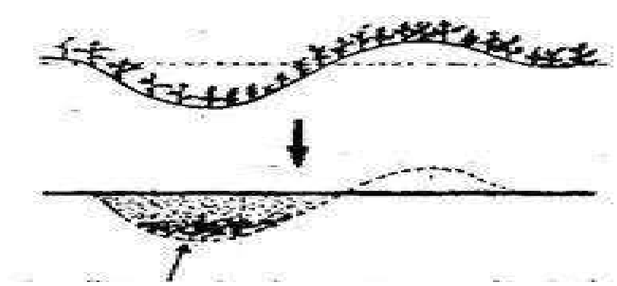


Planting along thedirection of slope



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

3.Modified Slope Mulberry



Planting along the direction of slope

Small trees, bushes are buried in the depression

4.8 Soil erosion

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.

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.

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.

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.

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 0.3-0.7mm/sec. It is the second stage of erosion.

Gully erosion

Increase drill erosion increases channelization of runoff. When the water flow to a vast loping 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.

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.

Landslides

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

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 downstream. This results in overflow and stream – bank erosion.

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 raindrops is absorbed by vegetation of soil surface, thus no breakdown 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.

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 percent 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)

Degree of Slope	Organic	Total	P2O5	K2O	CaO	MgO
0.5%	86.5	5.8	10.7	42.8	53.8	41.4
1.5%	92.8	6.5	11.1	52.9	59.2	78.5
3.0%	173.9	19.8	23.5	117.8	23.2	211.8

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 un ploughed 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 percent.

3) Mulching with plant materials reduce soi1 1oss 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 soi1 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 agronomica1 practice also plays a vital role to reduce runoff. Application of manures, fertilizers, increasing in filtration 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 under taken.

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-

estab1ishment of vegetation is essential to avoid serious erosion and to maintain ecological balance.

10) Contour trenches are made in non-agricultura11and 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.

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.

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 sandblasting. Wind velocity of 8-10 m can carry 490 million tones of soil per hectare.

2. Temperature and rain fall 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.

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

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.

Control measures

1. Close growing crops are more effective. Along barrier of a several rows of trees across wind direction is useful for soil and moisture conservation.
2. Trees like Pre suppose specigera; Albizzia amare, Tamarindus indica, are suitable for climatic conditions of the desert.
3. Rough and cloudy field surface with more than 50 percent 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 Texture and Humus

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 sub moist (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.

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

<table>
<tr><th colspan="2">General Terms</th><th>Basic Soil Texture</th></tr>
<tr><th>Common Name</th><th>Texture</th><th></th></tr>
<tr><td rowspan="2">Sandy Soil</td><td>Coarse</td><td>Sandy, Loamy Sand</td></tr>
<tr><td>Moderately Coarse</td><td>Sandy Loam
Fine Sandy Loam</td></tr>
<tr><td rowspan="2">Loamy Soils</td><td>Medium</td><td>Very fine Sandy Loam
Loam
Silt Loam</td></tr>
<tr><td>Moderately fine</td><td>Silt
Clay loan
Sandy clay loam Silty clay loam</td></tr>
<tr><td>Clayey Soils</td><td>Fine</td><td>Sandy clay Silty clay Clay</td></tr>
</table>

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 there mains of plants and animals. Chemically humus represents 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.

Mineral	**Percentage**
Carbon	50
Oxygen	35
Nitrogen	5
Hydrogen	5
Ash (containing P, K, S and others)	5

Humus available in surface layers of 3 important soils:

Soil group	**percentage organic carbon**
Deep black soil	0.34-0.77
Red and laterite soil	0.68-6.53
Alluvial soil	0.28-1.10

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 store house of plant nutrients. The decomposed humus releases all the nutrients are available to plant.
5. There find humic acid or it satrium compound ac celebrates 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.

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.

Soil pH

Mulberry cannot 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, a pH from 6.5 -7.0 is considered to be the best range in which most of the nutrients are desirably available to the plants. Lime is applied to correct pH.

4.10 Soil Moisture and Conservation Methods

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.

Methods of conservation

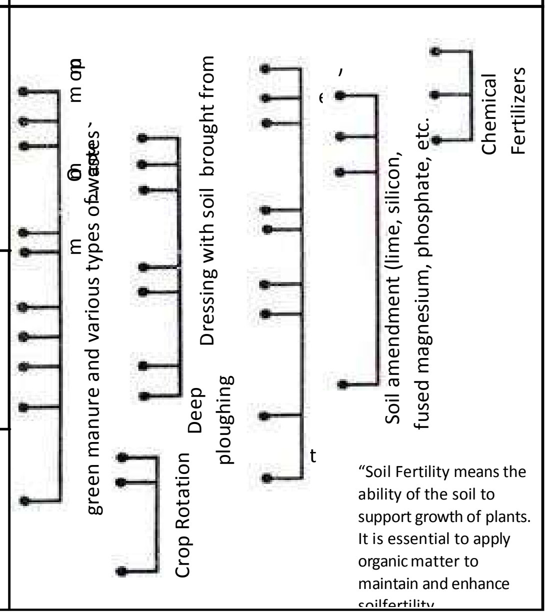
There are several factors i.e. wind, water, waves which contribute to loss of soil and soil moisture which are vital for plant growth. Besides this loss of nutrients in the soil surfaces, reduction in storage capacity of reservoirs, to water and soil also occur. This is due to faulty agricultural practice. The soil erosion depends on

(i) the type of soil-texture, structure and 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

Soil Fertility Factor		Methods of Conserving soil fertility
1. Chemical Properties	1. Amount of nutrients supplied. 2. Slow but continuous supply of nutrient. 3. Reaction, redox potential and buffering capacity of salt concentration	
2. Physical Properties	1. Water supply capacity, seepage, water drainage and water permeability. 2. Aeration	
3. Biological Properties	1. Promotion of bio-degradation (decomposition of organic matter nitrogen, fixation etc.) 2. Suppression of parasitic activity.	

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

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

Mulching

About 60-75 percent 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 improves oil 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 lows 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.

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.

Anti transpirant

The water absorbed by the plant is lost to an extent of 99 per cent during transpiration. Thus, anti transpirant 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, ref1ecting type, growth retardants, are very effective.

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

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 areas.

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.

4.11 Mechanization in Mulberry Cultivation

Today, the Indian sericulture industry is facing a stiff challenge from imported silk mainly from Chinese silk which is not only superior in quality but also cheaper in cost. We shall, therefore, improve quality and quantity of cocoon production at the same time reduce the cost of production of indigenous silk. The sericulture industry in India is highly labour intensive. In India, over 65-70 % cost of cocoon production accounts for labour wages for different activities.

Hence, we should reduce labour dependency to reduce cost of cocoon production especially through mechanization of mulberry cultivation and silkworm rearing, which not only enhances cocoon production but also reduces cost of production. Mechanization is must for large scale mulberry cultivation and silkworm rearings.

Why Mechanization in Sericulture?

Mechanization in sericulture is required for:

- Increasing the productivity through large scale sericulture activities.
- Timeliness and quick process in various mulberry cultivation and silkworm rearing activities.
- Maintaining hygiene during silkworm rearing.
- Reducing labour cost in mulberry production and silkworm rearing
- Cutting down the cost of production of silk cocoons
- Improving the quality of cocoons and silk.

1. Mechanization in Mulberry Cultivation

Mulberry cultivation is very important in sericulture. A good quality of mulberry leaves leads to production of good quality and silk rich cocoons. In recent years, the cost of production of mulberry leaf has increased due to increase in labour wages and cost of inputs like fertiliser and water. Nearly, 60 -70 % of cost of production of silk cocoons accounts for mulberry leaf production, over 65-70 % expenditure goes for labour wages for intercultural and other operations. Hence to reduce the cost of production of silk cocoons, we must reduce cost of production of leaf. Appropriate mechanization such as adoption of tools, equipment and machines for land preparation, cutting preparation, intercultural operations, chemical spraying and shoot harvesting can reduce cost of mulberry leaf production at least by 35-40 %.

1. Land Preparation for Mulberry Plantation

Mulberry is a perennial crop. Once planted, it lasts for 12-15 years. Therefore, the land for mulberry should be thoroughly prepared before plantation. Land for new mulberry plantations can be prepared faster and at less cost by using tractor operated mould board or disk plough, cultivators and harrows. A thorough land preparation helps in faster establishment of mulberry plants

Fig 4.2

2. Mulberry Cutting Preparation Machine

Mulberry is propagated through cuttings. A worker manually makes 1,500 to 2,000 cuttings in a day. With help of mulberry cutting preparation machine developed by CSRTI, Mysore 1,400 to 1,500 cuttings can be prepared in one hour.

Fig 4.3

3. Mulberry Plantations and Intercultural Operations

CSRTI, Mysore developed plantation geometries like paired row and 3M to facilitate mechanized operations. Mechanized cultivation reduces cost of leaf production and permits carry out work at faster rate. Power tillers, power weeders and tractor operated cultivators could be used for intercultural operations in mulberry gardens.

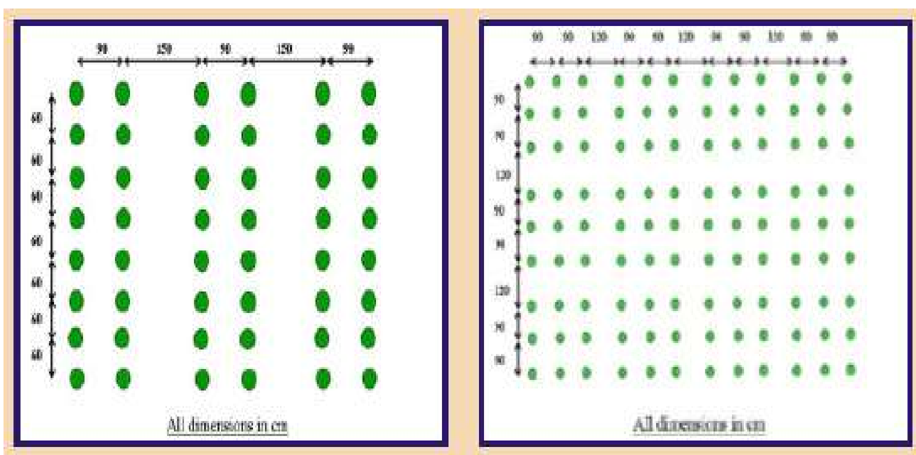


Fig.4.4 Spacing

4. Mechanized Spraying of Chemicals in Mulberry Gardens

Timely control of diseases and pests is very much required for production of healthy mulberry leaves. Farmers can spray chemicals uniformly in less time with help of self-propelled CSRTI sprayer, TNAU power tiller mounted sprayer and ASPEE tractor mounted sprayer.

Fig 4.5 Mechanized spraying

5. **Mulberry shoot harvester**

These days shoot rearing has become very popular in Southern India, Maharastra and Madhyapradesh as its saves labour, time and expenditure. It also facilitates large-scale silkworm rearing. Indian farmers use traditional sickle, serrated sickle, and single action pruning saw for harvesting mulberry shoots. CSRTI, Mysore developed knapsack type bush cutters for mulberry shoot harvesting. About 600-800 kg shoots can be harvested in one hour. The institute has also developed a power tiller operated mulberry shoot harvester for medium and large farms. It works well in paired row plantation and can harvest 1,000-1,200 kg shoots per hour.

Fig 4.6 Mulberry portable pruner and Power tiller operated mulberry shoot harvester

Summary

- Rocks are parent materials over which soils developed. There are igneous, sedimentary, meta morphosis 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 soil pH? What is the suitable p^H 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 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.

8. "Soil – erosion-a Threat to cultivation" –comment.

9. Define mechanization in sericulture and write about its importance

III. <u>Short Notes</u>

1. Red soil 2. Humus 3. Soil temperature 4. Dubba soil 5. Soil Testing
7. Topography 8. Layout of plantation 9. Land preparation.

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. Mulching of soil and uses of mulch materials.

UNIT 5

Mulberry Planting Methods

Learning Objectives

After studying this chapter you will be able to.

- Able to identify different mulberry varieties
- Understand importance different planting methods.
- Know about sexual and Asexual propagation.
- To learn about Growth regulators.
- Identify stock and scion and its importance.
- Understand about trench layering to prepare more than one plant from one branch.

5.1 Introduction

There are about 68 species of the genus *Morus*. The majority of these species occur in Asia, especially in China (24 species) and Japan (19). Continental America is also rich in its *Morus* species. The genus is poorly represented in Africa, Europe and the Near East, and it is not present in Australia. In India, there are many species of *Morus*, of which *Morus alba, M. indica*. *M*. *serrata* and *M. laevigata* grow wild in the Himalayas. Several varieties have been introduced belonging to *M. multicaulis*, *M. nigra*, *M. sinensis* and M. *philippinensis*. Most of the Indian varieties of mulberry belong to *M. indica*. In China there are 15 species, of which four species, *Morus alba*, *M. multicaulis*, *M. atropurpurea* and *M. mizuho* are cultivated for sericulture. The major area is in the tropical zone covering Karnataka, Andhra Pradesh and Tamil Nadu states, with about 90 percent. In the sub-tropical zone, West Bengal, Himachal Pradesh and the north eastern states have major areas under mulberry cultivation.

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 parental characters of the plant, speed in raising large number of saplings, adaptability to a 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 multivoltine areas like Karnataka, Andhrapradesh, Tamilnadu 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 seedling 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 meagre, 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 Selection of mulberry varieties

Characteristic features of a good mulberry variety:

1. High degree of nutrient value.
2. High moisture content and retention capacity.
3. Succulence for longer duration.
4. High leaf yield.
5. Good rooting capacity.
6. Drought resistance.
7. Disease resistance.

Choice of Mulberry variety:

The choice of mulberry variety to be planted should always depend on the prevailing conditions of soil, water and climate in the area. Under normal conditions, V1 proved as the best mulberry variety. Good irrigation facilities and nutrient management are necessary to exploit its optimal potential.

However, if any special conditions or resource constraints are prevailing such as high soil pH, alkalinity, high water salinity, poor water resource, shaded conditions of the garden etc., or to meet some special requirements such as exclusive chawki garden (for CRC) etc., there are different alternative choices of mulberry varieties which can suit such conditions. Hence, the choice of mulberry variety to be planted should always be made keeping in view all these factors in mind.

V1 (Victory 1): It is a high yielding mulberry variety suitable for irrigated conditions. It carries high leaf moisture content and moisture retention capacity. It requires good irrigation facilities and nutrient management in the garden to exploit its potential. The leaf yield is about 60 MT/ ha/ year. It is the ruling variety in South India.

S36: It is an irrigated mulberry variety mainly suitable for chawki rearing. It carries high leaf moisture % and the leaf is more succulent. The leaf can also be used for adult age rearing. The leaf yield is about 40-45 MT / ha/ year. The rooting ability is low (48%) as compared to other recommended varieties (V l: 94%). If the temperature is below 13 °C in winter, dormancy can be observed in S36. Hence, the plant growth is poor in severe winter conditions.

S30: It is a semi-dwarf, mulberry variety with short inter nodal distance and is suitable for irrigated conditions. Leaf yield ranges from 35 to 36 MT/ ha/ year.

S13: Drought resistant variety recommended for both irrigated and rain fed conditions. Leaf yield is about 44 MT /ha/year under irrigated and 16-18 MT/ha/year under rain fed conditions.

S34: It is a drought resistant variety recommended for black cotton soils. It can grow under both irrigated and rain fed conditions.

The leaf yield is about 45 MT /ha /year under irrigated conditions and about 16 -18 MT under rain fed conditions.

G2: It is a new evolved mulberry variety with fast growth and high leaf moisture content. The leaf is highly succulent and good for chawki rearing. Hence, this variety is especially suitable for CRC chawki gardens. The leaf yield is about 35 MT/ ha / year. About 65,000 DFLs can be chawki reared in 1 acre per year.

G4 (*M. multicaulis* x S30): It is a newly developed high yielding variety for irrigated conditions. The growth is fast with high branching capacity. Under assured irrigation conditions the leaf yield is around 65 MT/ ha/ year.

Sahana (K2 X Kosen (Japan): It is a shade tolerant mulberry variety suitable to grow under coconut plantations. It is fast growing and has high leaf moisture content. It is convenient if the age of the coconut garden is less than 3 years or more than 30 years, and the spacing in coconut plants is at least 25 ft x 25 ft.

AR 12: It is an alkaline resistant variety which can be grown even if the soil pH is high (8.5 to 9.5). The leaf yield ranges from 25 to 30 MT/ha/year under alkaline conditions. Under normal conditions of the soil (normal pH) the leaf yield will be higher (about 45 MT/ha/year).

MR-2: It is a mildew resistant variety developed by Dept. of Sericulture, Tamilnadu at their experimental Station, Coonoor during 1970s. This variety is very popular in Tamilnadu. This variety is better suited for high altitude areas where low temperature prevails. It is rated high for nutritional level of leaves and hence susceptible to attacks by sucking insects. Leaf yield ranges from 25 to 30 MT/ ha/ year.

Viswa (DD): It is a selection variety collected from Doon valley of Uttaranchal. It has a good rooting and sprouting capacity Due to fast growth 6 harvests can be taken every year. Leaf yield ranges from 40 to 45 MT/ ha/ year. It responds well for higher doses of nutrients and irrigation. Suits well for shoot harvest system under wider spacing and hot climatic regions.

RFS-135 and RFS-175: These two varieties are recommended for irrigated conditions. Though these two varieties are suitable for rain fed conditions also, it is not recommended because, its performance under irrigated conditions is very encouraging.

RC-1 and RC-2: They are resource constraint varieties. These varieties can thrive well under semi-irrigated conditions i.e, 3 or 4 irrigations are sufficient in the entire crop duration. Further, even with 50% of the recommended fertilizer doses, the leaf yield is encouraging. The leaf yield is about 30 MT/ ha/ year under semi-irrigated conditions, and more than 45 MT if the irrigation frequency is normal.

Anantha: It is a high yielding variety recommended for Southern India in 2011-12. It is a clone from RFS-135 and developed at RSRS, Ananthapur (AP). This variety possesses many good agronomic characters like high rooting ability, fast growth and deep root system. Leaves are un lobed, thick, deep green in colour with high moisture content. The plants are comparatively tolerant to foliar diseases, root rot, root-knot and tukra infestation. The leaf yield is about 60 MT/ha/Year.

General Recommendation of Mulberry for different zones:

Zone	**Rain fed**	**Irrigated**
South zone	S13, S34 (AP, K, TN)	VI, S36, Vishwa, Ananta (AP, K & T'N)

Eastern zone	S1635 (WB, 0 & A), S1 (WB)	S1635 (WB_4O&A)
North zone	Chinese white (J&KHP) 5146 (Majra)	Chinese white (J&K, UP & MP)

Leaf yield in different popular Mulberry varieties (MT/ha/Year)

Variety	Local	K2	S54	S36	V 1	S13	S34
Irrigated	25	35	42	40	60	44	45
Rain fed	11	13	NR	NR	NR	16	17

5.3 Mulberry Planting Methods

The old and traditional irrigated methods of mulberry plantation like strip method, row method, pit method and other close spacing methods are replaced by wide spacing systems, which are suitable for large scale mulberry cultivation and to have mechanised cultural operations and quality leaf harvestings. The following are the best and successful methods of mulberry plantation suitable to tropical areas.

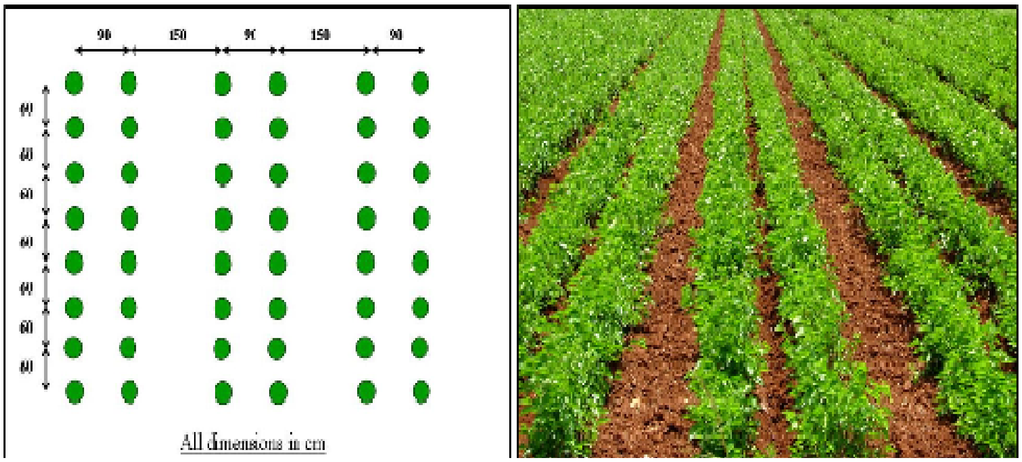
1. Paired row Mulberry plantation:

In Paired row plantation the mulberry plants are placed in rows which are at distance of 90cm (3') from each other. A pair of plant row is distanced by 150cm i.e., (150+90) X 60. Here, each plant occupies 0.8 m2 (8ft2) and there are 12,500 plants/ha. In paired row system of plantation inter-cultivation, power spraying and harvesting of shoots for large scale rearing is done with tractor and power tilled operated machines, which saves time and labor and also cost of production of mulberry.

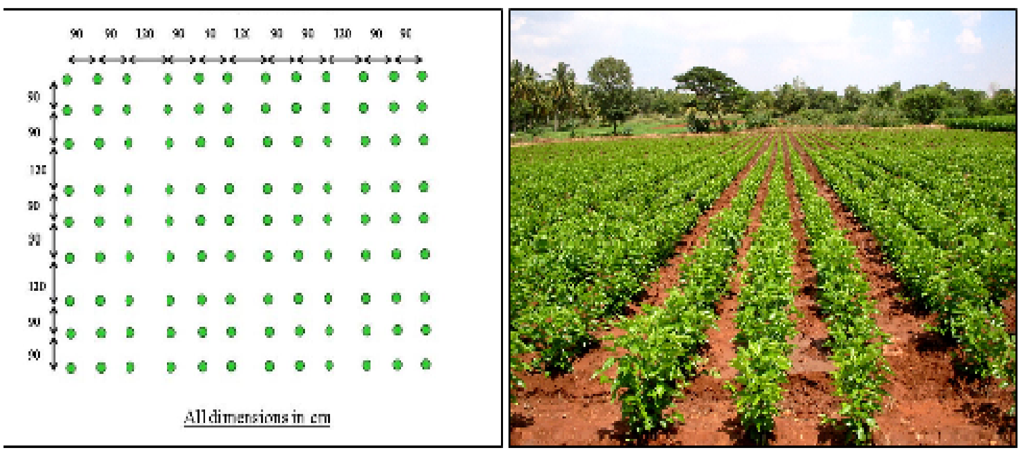
2. 3M Plantation

The sole constraint of Paired row plantation is that tractor or power tiller movement is feasible only along the row and for cross ploughing manual digging or bullock plough must be used. For cross ploughing with a tractor cultivator or power tiller, CSRTI, Mysore developed 3M plantation. The following figure shows the schematic diagram of arrangement of the mulberry plants in 3M plantation. CSRTI, Mysore developed plantation geometries like Paired row {(90cm + 150cm) x 60 cm} and 3M {(120cm+90cm+90cm) x (120cm+90cm+90cm)} to facilitate partial and full mechanised operations, respectively in mulberry gardens.

The following figure shows the schematic diagram of arrangement of the mulberry plants in a paired row plantation.



Paired row plantation



3M Plantation

3. Tree plantation

The mulberry plants which can grow tall with a crown height of 5 - 6 feet from the ground level having stem girth of 4 -5 inches or more is called tree mulberry. This method is generally practiced in rainfed mulberry cultivation where plants were planted in pit system and can be grown as trees for continuous leaf harvest in tropical areas. In recent times tree plantation is in practice even in irrigated systems, but utilization of water is minimized, and quality and quantity of leaf produced is also on par with other methods. Plants established in this method withstand the drought and various adverse conditions.

Method of plantation: Pits of size 4’x4’x4’ (L x W x D) are prepared with spacing of 10’x10’ or 8’x8’ between the plants and row. The saplings of 8 - 10 months old are specially raised are selected for planting and are planted in pits by half filling with equal quantities of red earth, sand and FYM. Plants are irrigated with drip method, at least 2 lit of water/day is given to each plant. With this spacing we can accommodate 400 to 450 plants in1acre of land. Initially single shoot is allowed to grow to the height of 6-7 feet and are pruned at the tip of plants. Later lateral branches at the tip are only allowed to grow remaining are removed. Like that plant is trained to grow as tree, repeated pruning at the top allow plant for profuse branching. Shoots can be harvested after every 45-50 days like irrigated bush system. Second year onwards leaf produced on each tree can feed 1 laying of worms ie., 450-500 silkworms. Therefore with one acre tree plantation 400-500 plants one can rear 400 -500 DFLs.

Fig-6: Pruned mulberry saplings after one year of plantation

Fig-1: Two years old mulberry tree plantation

Advantages of tree plantation:

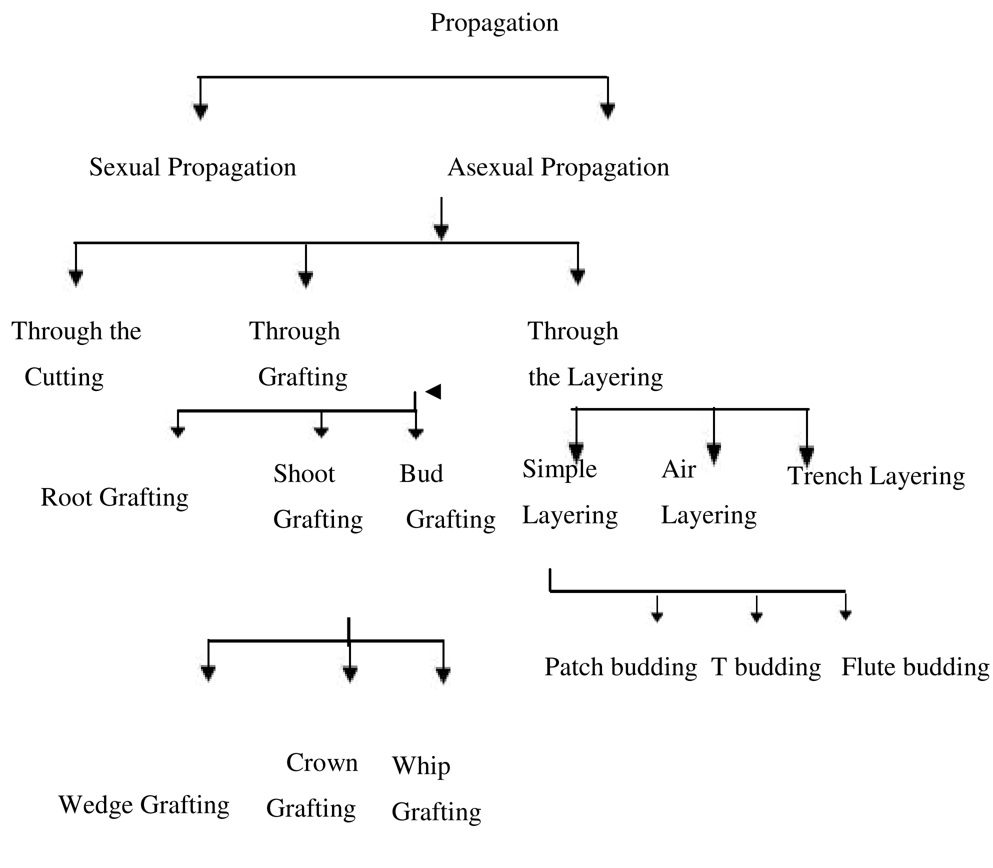
1. Tree plantation is suitable to drought areas where water utilization is minimized with drip irrigation
2. Trees withstand drought conditions.
3. Disease and pest incidence is minimized, and its controlling is easy.
4. Weed population is also controlled as water is available only in pit.
5. Only 2 lit of water is enough for each plant/day
6. Leaf on shoots is quite suitable for 3^{rd} age (late age) silkworm.

5.4.1 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 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.

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 litre volume.

Nursery plots

Plants grown from a seed is called seedling and 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 M size are prepared with a provision to protect young seedling form excessive light and temperature.

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 2-3cm between rows and 1 cm between seeds is advisable for better germination. After sowing, holes are covered with soft soil and water is applied gently.

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 leaves 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 coloured light delays seed germination.

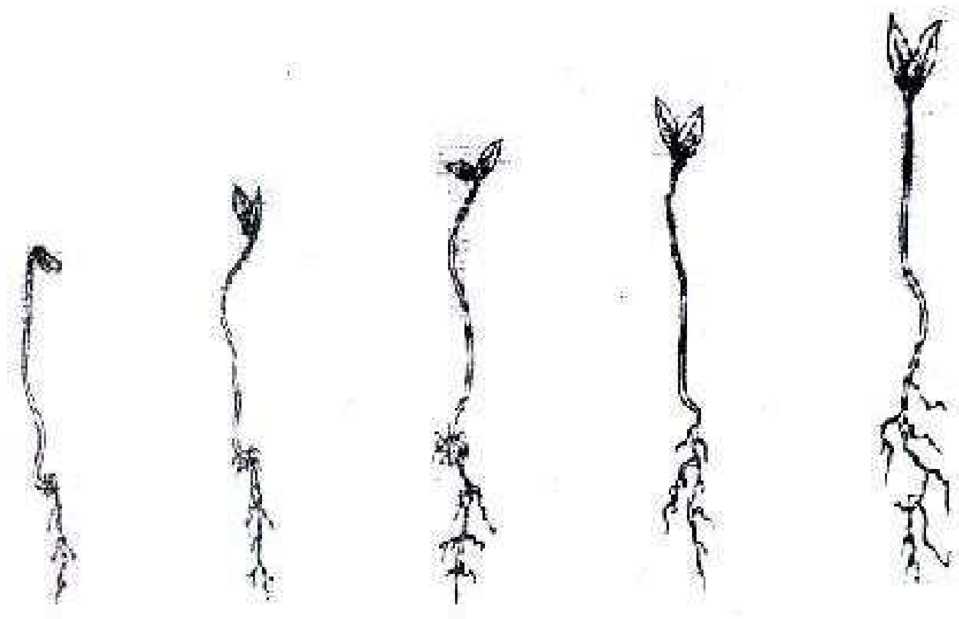


Fig 5.1 Stages of Seed Germination

Propagation methods of mulberry

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. They can be either used for grafting (stock plant) or allowed to grow for two years to raise tree plantations.

5.4.2 Asexual propagation

It is the most popular method adopted in moriculture. It favours 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.

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.

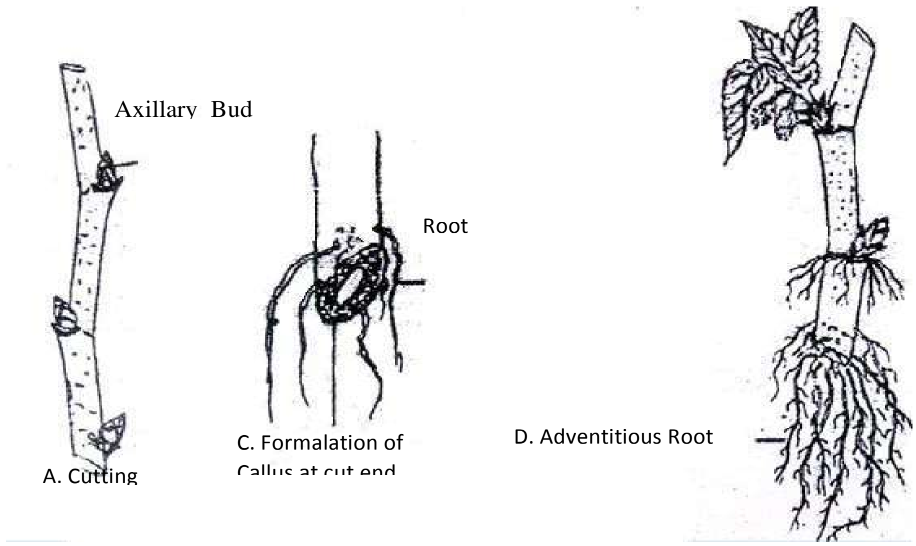


Fig. 5.2 Cutting and its Developmen

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.

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 –Dichloro phenoxy 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.

Grafting method

It is a technical joining of a branch of one plant into a rooted plant in such a way that they unite 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.

Basic principles of grafting

- Compatibility of stock and scion

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

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.

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) 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^{0}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.

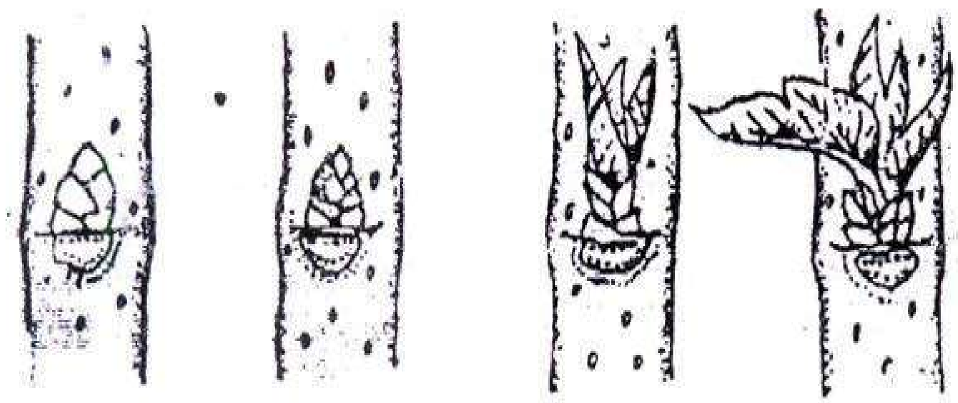
5.3.2.2 Shoot grafting

The scion is inserted into the stock stem is called shoot or stem grafting.

It is of many types.

a. **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



Winter Bud | Bud breaking stage | Swallow Beak (Leaf Emergence Stage) | Leaf Opening Stage..

Shoot Grafting

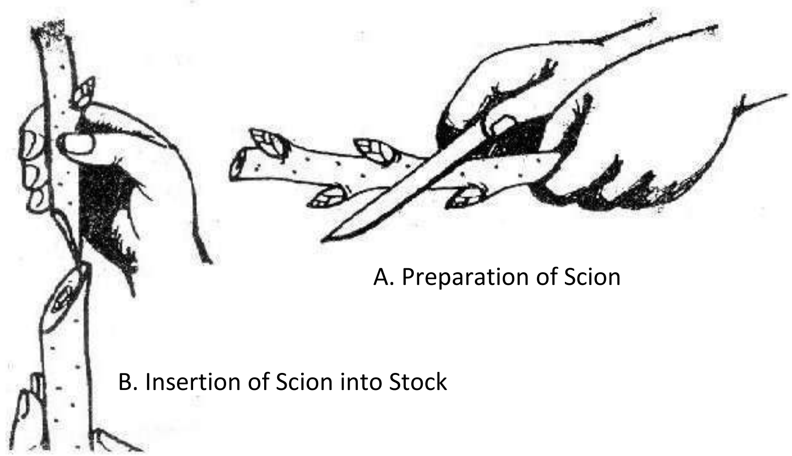


Fig. 5.3 Shoot Grafting

Crown Grafting

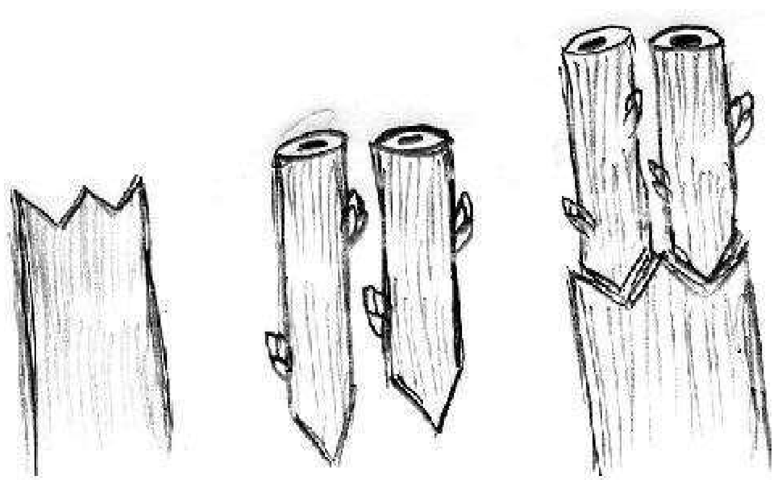
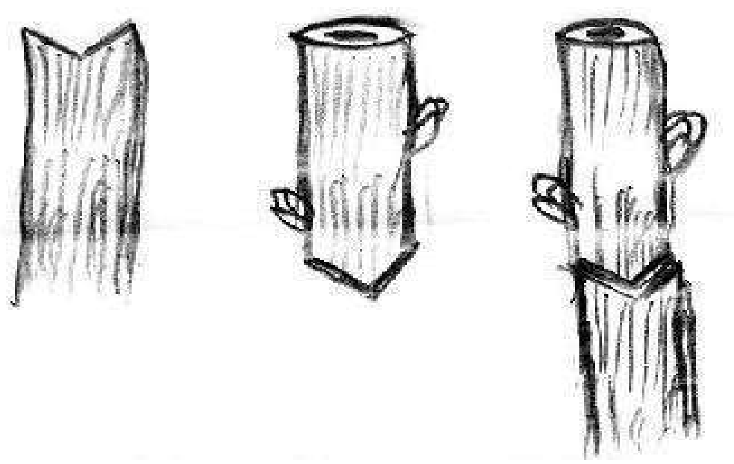


Fig. 5.4 Crown Grafting

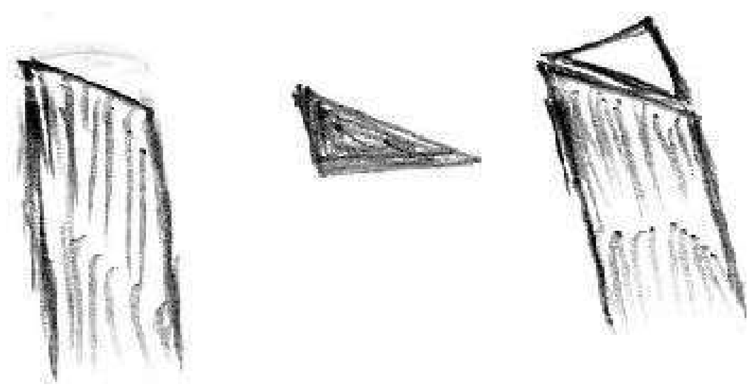
Wedge Grafting



Stock **b. Scion** **c. Graft Union**

Fig. 5.5 Wedge Grafting

Whip Grafting



Stock **b. Scion** **c. Graft Union**

Fig. 5.6 Whip 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.

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.

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 10cm 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.

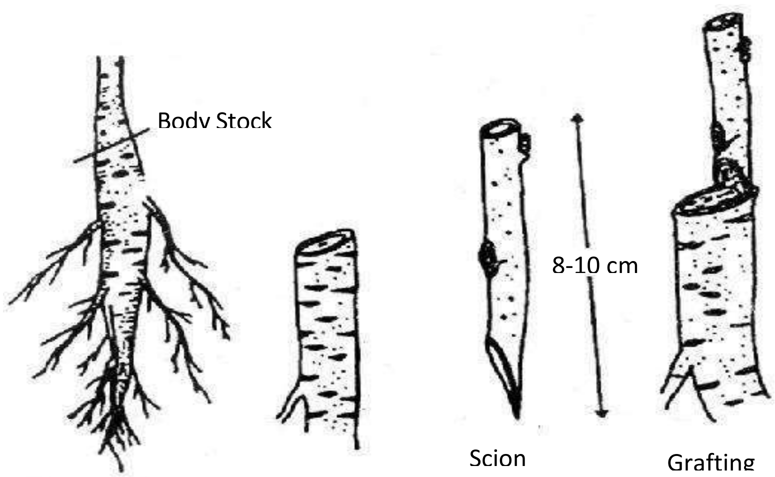


Fig. 5.7 Root Grafting

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.

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.

5.3.2.3 Bud grafting or Budding

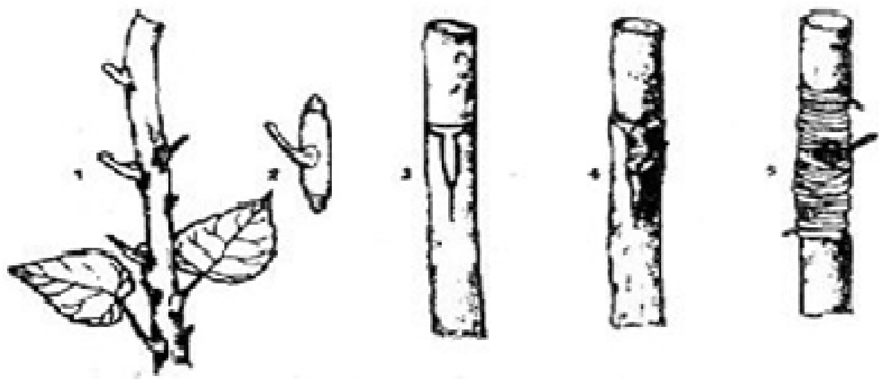
It is a better method when the scion material is scarce. In this grafting only one vegetative bud with a piece of bark is used as scion material thus called as bud grafting, which has all the advantages of grafting. It is much practiced in temperate regions of the country. The removed bud piece contains 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.

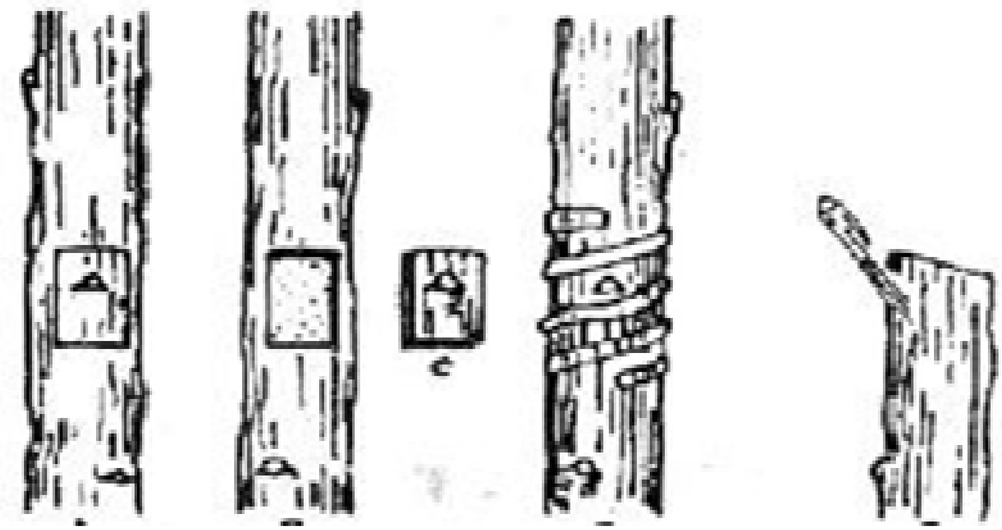


1. Bud Stick 2. Shield Bud 3. ‘T’ Shaped cut on stage plant 4. Inverted bud in T slot. 5. Bud Wrapper

Fig. 5.8 T. Budding

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.

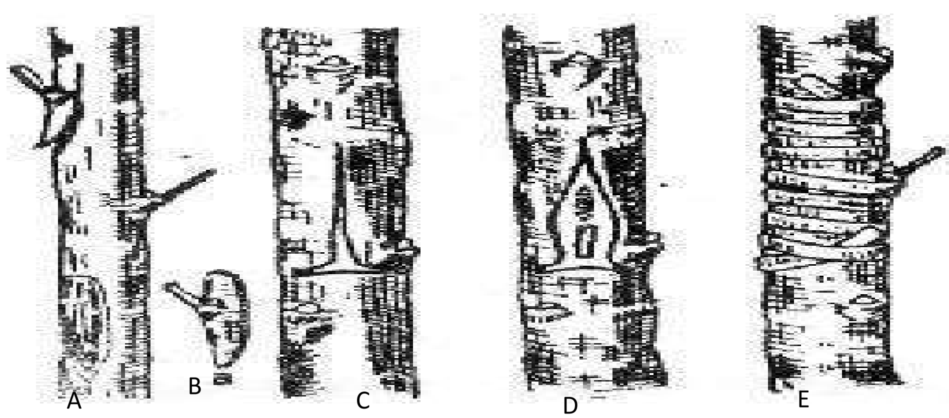
In **patch budding**, a patch of bark with an active bud is removed from the bark of scion. A patch of bark of similar size is carefully removed from the stock in the inter nodal region. Then patch with bud of the scion is inserted on to the stock and properly bandaged with a soft fiber and covered with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



A B C D E

Fig. 5.9 Patch Budding

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.

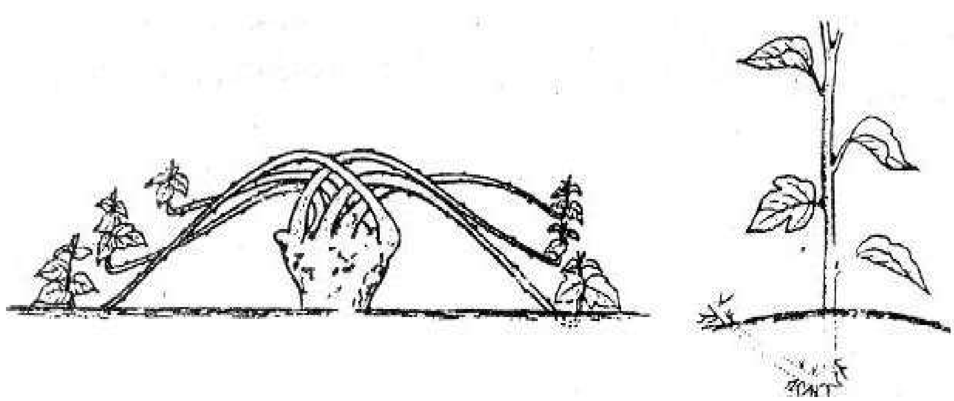
C. Bud ready for insertion. D. Bud inserted. E. Shoot growth from bud about a year later

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.

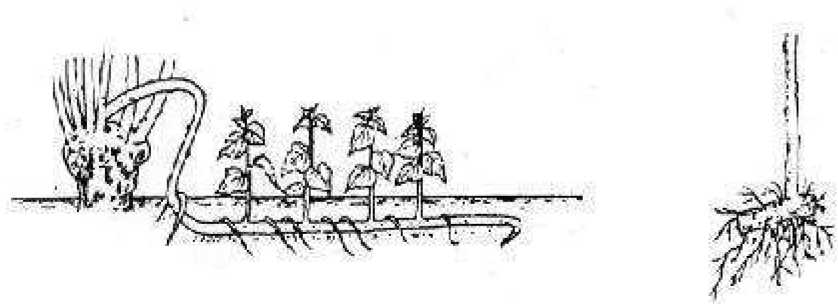
5.3.3 Layering

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.



A. Ground Layering B. Development of Roots

Fig. 5.10 Simple Layering



A. Trench Layering **B. Rooted Sapling**

Fig. 5.11

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.

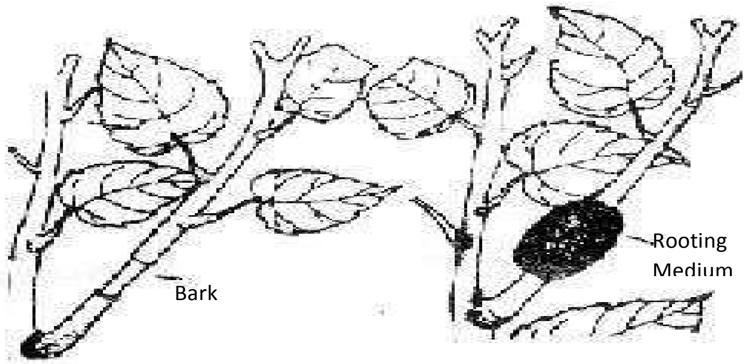


Fig. 5.12 Air Layering

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.

Summary

- Mulberry can be propagated sexually and asexually.
- Sexual propagation by seed. Asexual propagation by vegetative 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?

Long Answer Type Questions

1. What are the qualities of good medium?
2. Explain about sexual propagation of Mulberry.
3. Write about Root grafting.

4. Explain about shoot grafting.
5. Describe Bud grafting.
6. Explain about layering methods of mulberry.
7. 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

Mulberry Cultivation

1. Introduction
2. Cultural Practices
3. Garden Implements
4. Weeds and Inter-Cultivation
5. Pruning and Training
6. Importance of Water Shed
7. Methods of Irrigation
8. Detailed Study of Drip Irrigation

Learning Objective

After learning this chapter, you will be able to:

- know about the different garden implements required and how to use.
- learn about cultivation and cultural methods.
- Identify the weeds and its control.
- Learn types of pruning and training methods.
- Understand the types plantation and irrigation 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 form is necessary for easy harvestand inter cultivation (i.e., ploughing in the middle rows).

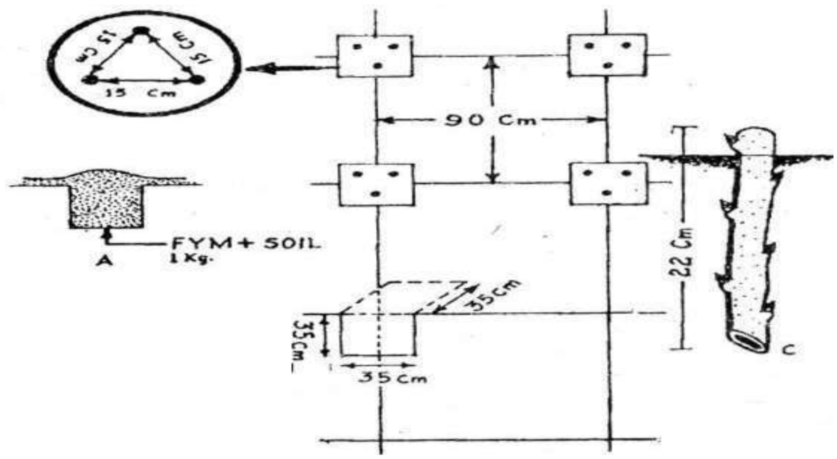
6.2 Cultural Practises

6.2.1 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 3 5 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

Fig 6.2 Plant Spacing for rain fed pit system

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

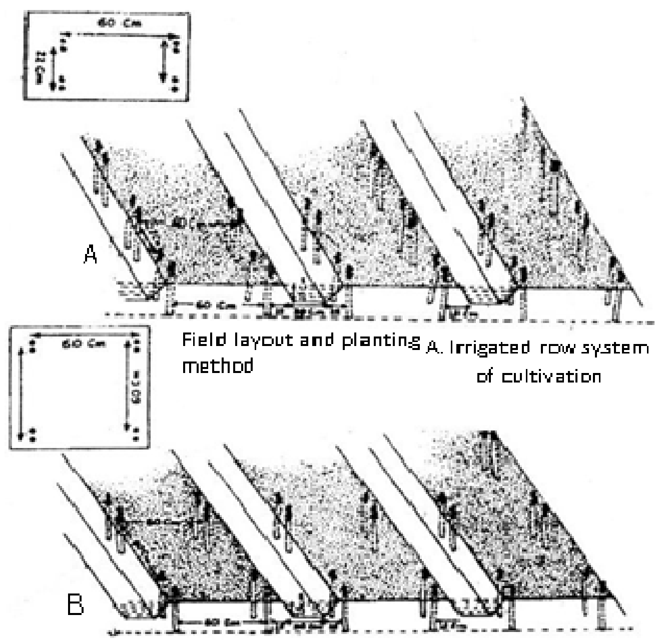
To a large extent mulberry is being cultivated under rainfed area. Three healthy cuttings should be planted in each pit in a triangular form with a distance of 15cm.Care should be taken to expose only one bud. In case of saplings, one sapling is enough per pit.

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

b. 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



B. Irrigated pit system

Fig 6.3 Field layout and planting system under irrigated condition

In the row system of plantation, the rows are 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 60 cm a part 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.

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.

Fig. 6.4 Paired row system

Spacing (90+90+120) X (90+90+120)

Table 6.1

Spacing for Mulberry

Sl. No.	Spacing	between Rows (mts)	Spacing between Plants (mts)
1.	Pit System (Rain fed)	0.9-0.75	0.9-0.45
2.	Row system (irrig)	0.45-0.60	0.45-0.60

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 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 0.30 to 0.45 m. On either side of ridges mulberry is planted at a distance 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 30 x 60cm. Plantation is taken up on either side of ridges with a spacing of 10-25 cm between the plant to plant.

6.3 Garden implements

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.

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).

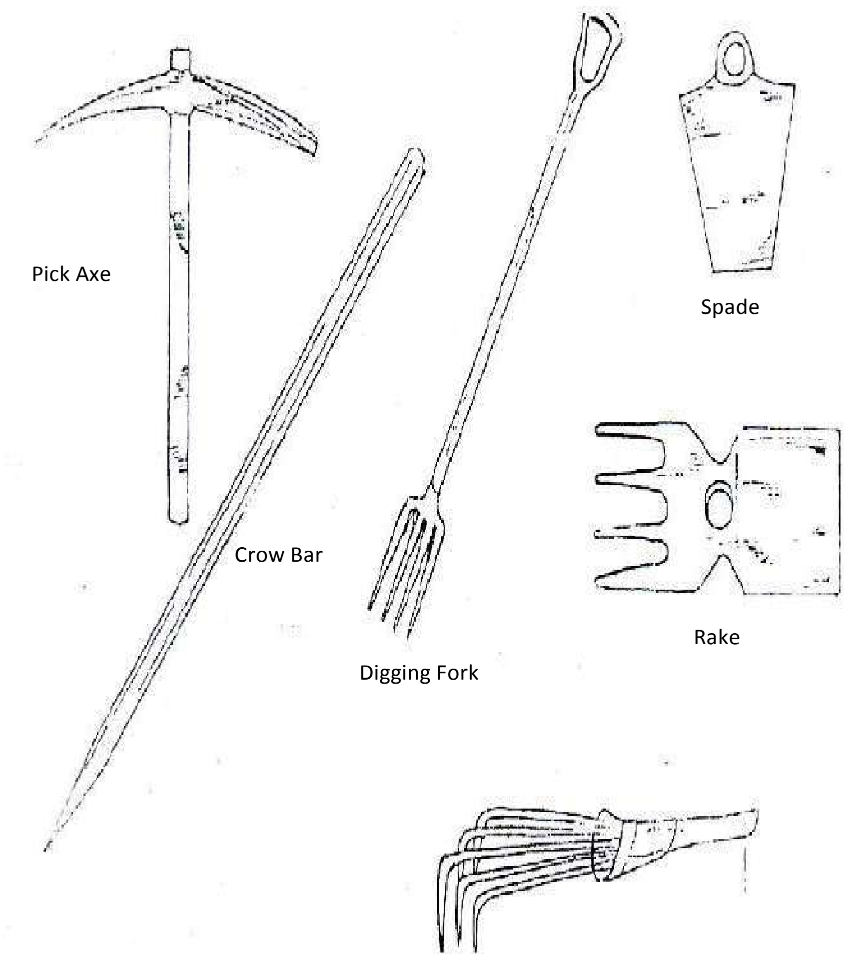
Crow bar: It is a 6' long iron rod with 2" diameter with one sharp, flat end used for deep digging, making pits in hard soil and also to move stones (fig.6.1).

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. 6.5)

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 use ful in hill areas. It is a better implement for loosening the moist soil and mixing manures in pits (fig.6.2).



Hand Cultivator

Fig. 6.1 Digging implements

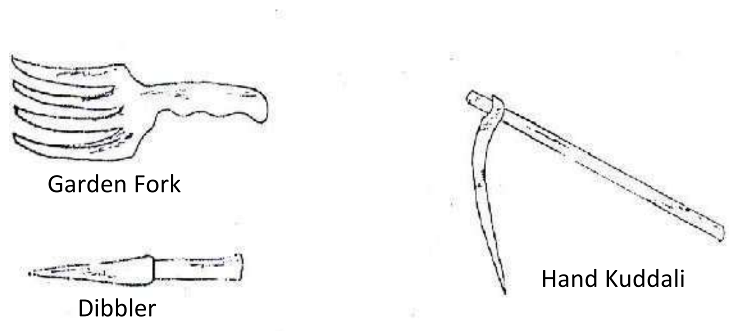


Fig. 6.2 Garden Implements

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 15cm. 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.6.2.1)

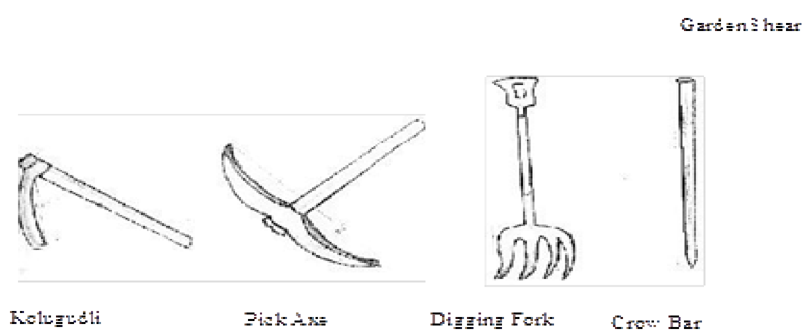


Fig 6.2.1

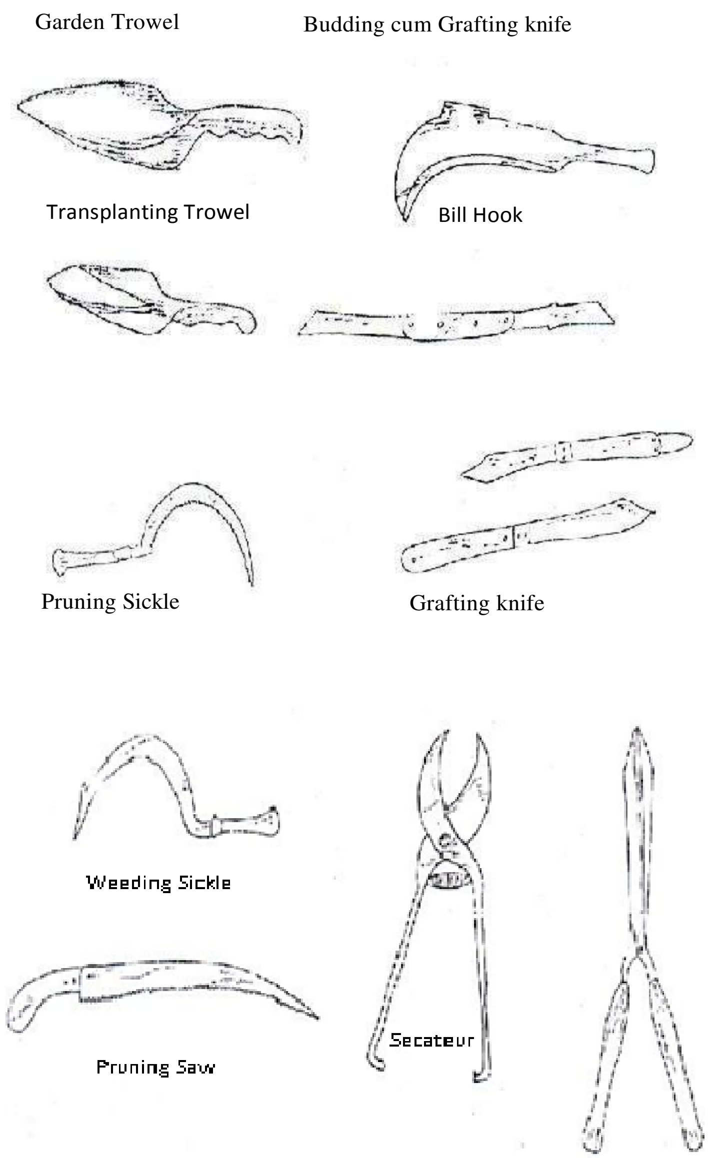


Fig 6.2.2 Garden impliments

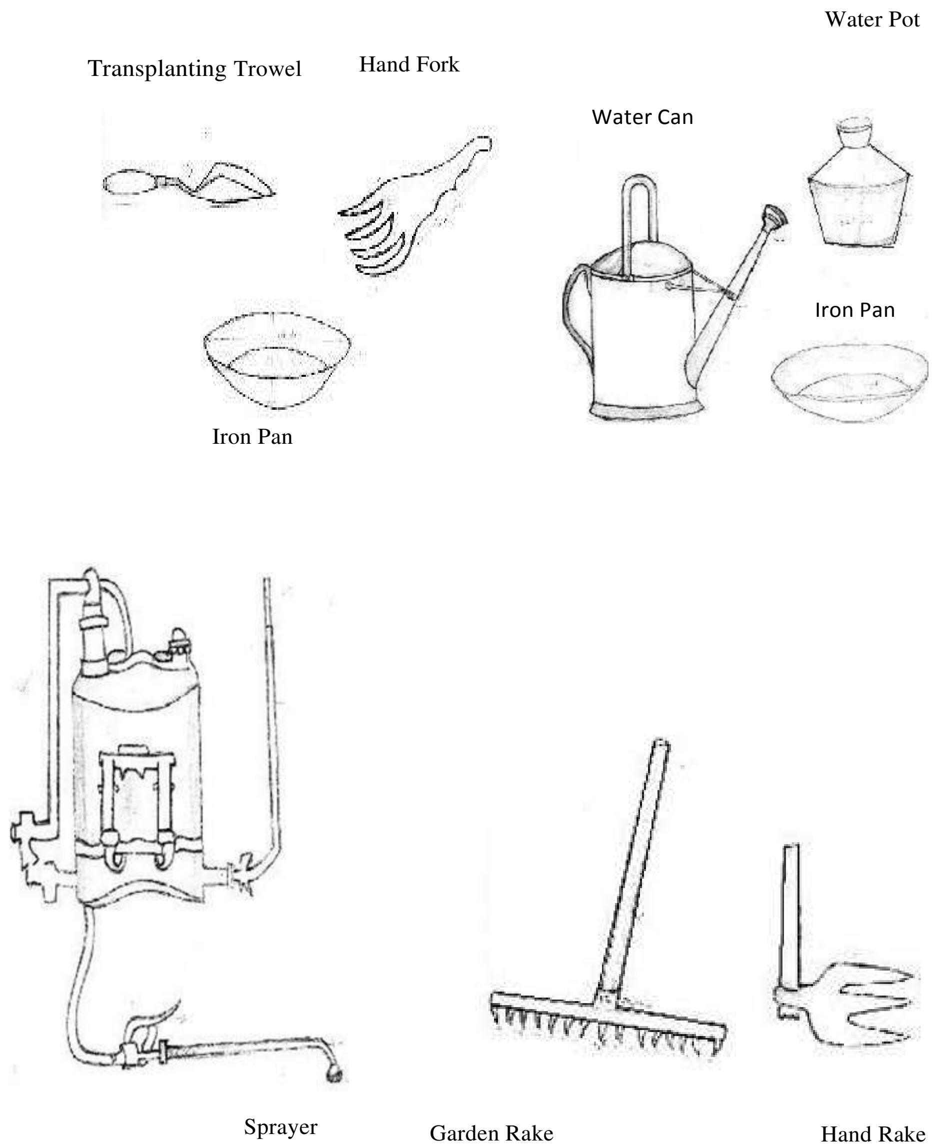


Fig. 6.2.3 Garden Implements

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.6.2.2).

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.6.2.2).

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.6.2.2).

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. 6.2.2).

Budding knife: It has a single blade 17 cm. long can be folded into a socket of 8cm.long. The other end of socket has 2.5cm size budder to lift the bud after making necessary incision (fig.6.2.2).

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. 6.2.2).

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. 6.2).

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 Coffman sickle with 5" long wooden handle. The inner edge is like saw blade. It is used for cutting small branches (fig.6.2.2).

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. 6.2.2).

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

Secateurs: It has two stouts, 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.6.2.2).

Garden shear: It has two metal blade s with plain edges with notch & wooden handle. The two blades move over each other. It is of8", 10", 18" long sizes. These big scissors usually used for clipping and pruning of plants (fig.6.2.2).

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.

Other Implements (Fig 6.2.3)

Water can with rose: It is made up of24 gauge G.I. sheet. The can is 24" diameter with 12" 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 gr. 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.

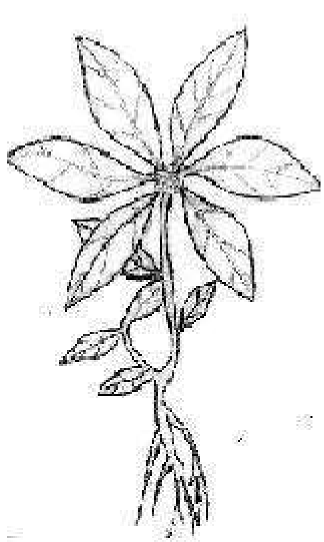
Wheel barrow: It is used for transporting manure, fertilizer, seedlings, saplings. It rests on two legs and moves with a gentle push.

6.4 Weeds and Inter- Cultivation

Weeds

Fig. 6.4.1 ***Phyllantha niruri***

Fig. 6.4.2 ***Achyranthus aspera***



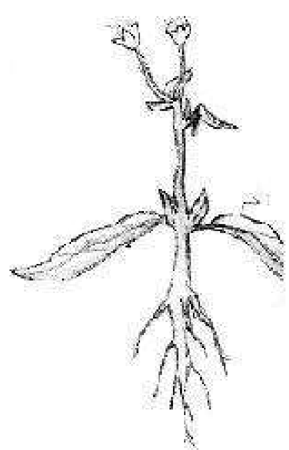
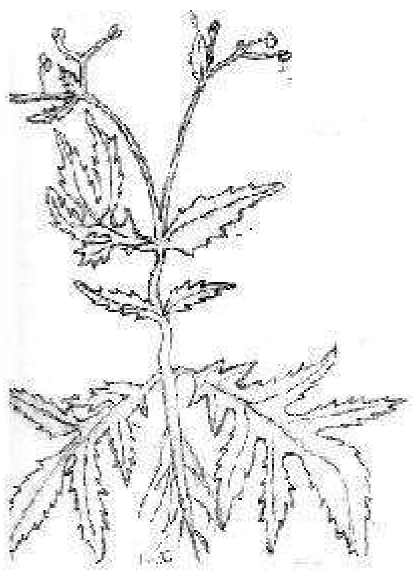


Fig. 6.4.3 ***Euphorbia geniculata*** **Fig. 6.4.4** ***Lagasco molis***



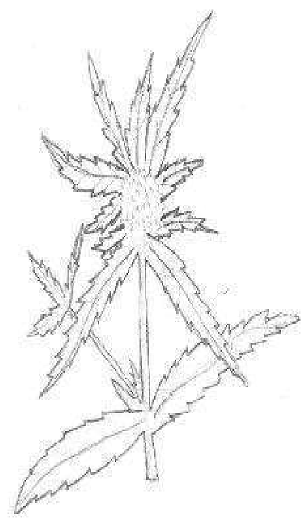


Fig. 6.4.5 ***Parthenium histeroforus*** **Fig. 6.4.6** ***Leucas aspera***

1. Parthenium hysterophorus **(wild carrot) :** It belongs to family Asteracae. 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 spreading it has become not only an agricultural weed, but a municipal weed as well.

1. Phyllatha niruri

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

2. Achyranthus aspera

1. It belongs to the family Labiatae.

2. It is common weed in mulberry garden.

3. Stem is soft, leaves are simple, and reticulate. Inflorescence is verticellaster flowers bisexual, zygomorphic.

Control: By uprooting.

4. Euphorbia geniculata

1. Family: Euphorbiaceae.
2. It is a herb, commonly found in mulberry garden.
3. Leaves are alternate.

Control : By uprooting and burning.

5. 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.

6. Legasco mollis

1. Family: Compositae
2. Flowers are female on the top

3. Leaves are opposite

Control: Deep ploughing and weeding.

7. 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

Euphorbia (Cynoden Tridax
hirta rohtundus dactylon Procumbance

Fig. 6.4.7 Mulberry Weeds

8. ***Cynoden dactylon*** **(Bermunda grass, Stargrass):**

It belongs to family Graminaeae, commonly called Devil's grass, Bermunda grass and stargras, It is a perinnial grass water long runners which strike roots at the nodes and extensive underground rhizomes. It occurs throughout the tropical, sub-tropical and semi-arid regions of the world. It is propagated by grains and under ground stems.

9. ***Phyllanthus niruri*:**

This weed belongs to family Euphorbiaceae. It is a glabarous annual herb. Leaves are small.

***10.Euphorbia hirta* (Garden spurge, Asthma weed):**

Belongs to family Euphorbiaceae, commonly called as spurge and Asthama 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 weed effectively.

***11.Trianthema parthulacastrum*:**

Belongs to family Aizoaceae, common name Horse purslanea 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.

12. ***Xanthium strumarium*:** Belongs to family Compositae. Common name Burd-weed. It is a course annual herb. Propagated by fruits.
13. ***Tridax Procumbens*:** Belongs family Compositae. It is a perennial herb. Propagated by achenes.

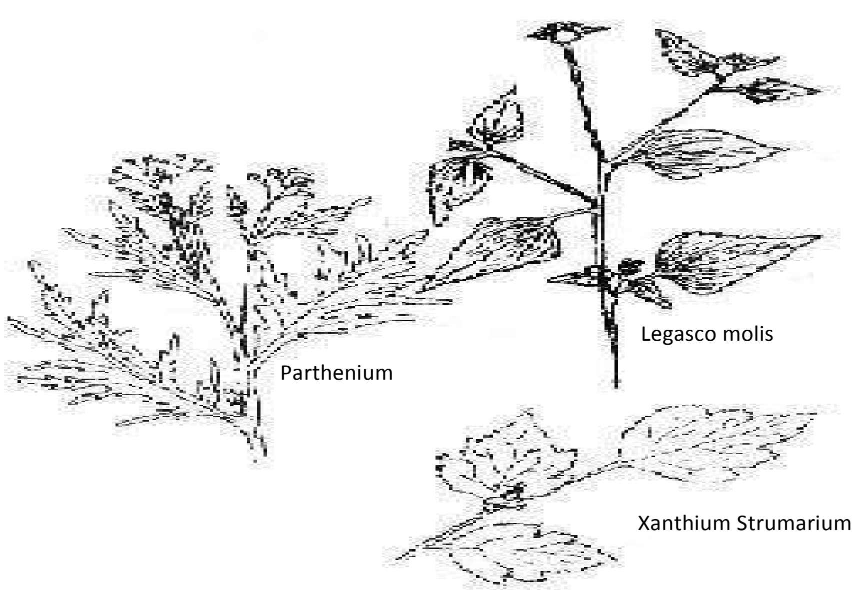


Fig. 6.4.8 Mulberry Weeds

***14. Cyprus rotundus* (Nugrass,purplenutsedge)**:

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 sub tropics. It is propagated by seed like nuts and underground stems.

6.5 Effect of Weeds on Mulberry

Today only 15 species of plants are cultivated to produce food grains to meet the demand of 90% of world population. However, 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 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 sun light. 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 is reduced. 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 harbouring 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 susceptible to attack by nematode pathogens.

Effects of weeds on mulberry results in

- It reduces the moisture content in mulberry leaf.
- Nutritive value becomes deficient.
- Normal growth rate comes down drastically.
- Reduction in crop yield.

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

- Physical method
- Inter cultivation
- Chemical method
- 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 favourable 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 levelling 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 first 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 Its. 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 *Parthenium hysterophorus*. Biological control, applies to destroy the weeds alone.

Precautions in using 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 buds.

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 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 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.

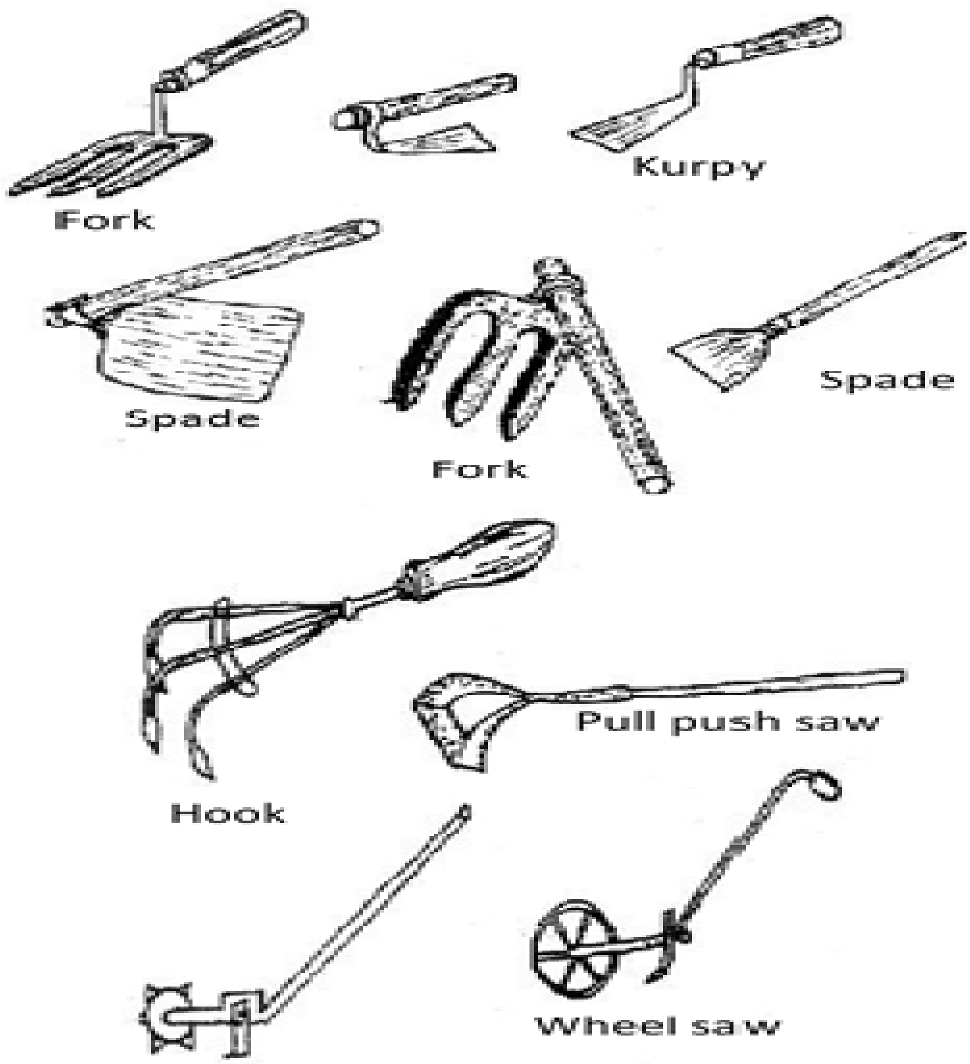


Fig. 6.6.1Weeding Implements

6.7 Pruning and Training

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. Overcrowding 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

- To maintain proper shape and size of plant
- To make cultural operation easier.
- To provide proper aeration and sunlight.
- To maintain convenient height for harvest.
- To induce higher foliage.
- To synchronize the leaf production and silkworm rearing
- 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.

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.

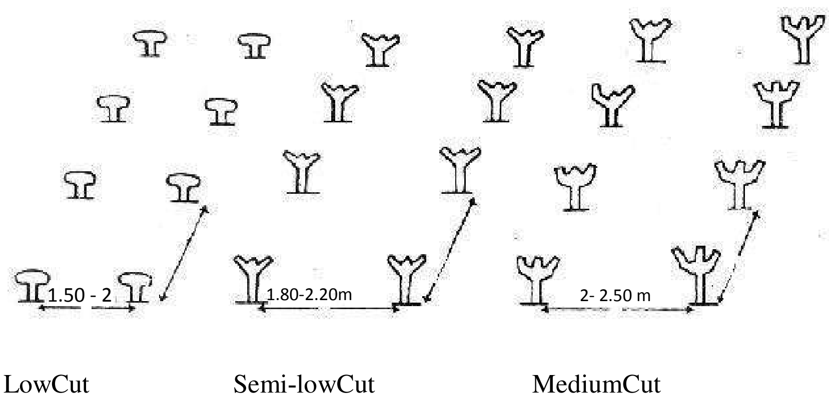


Fig. 6.7.1 Cut Forms

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 throughout 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 1 0-15 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

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

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

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

(f) Leaves mature rapidly

(g) Water content in leaves is relatively low

(h) 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 supply water 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.

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.

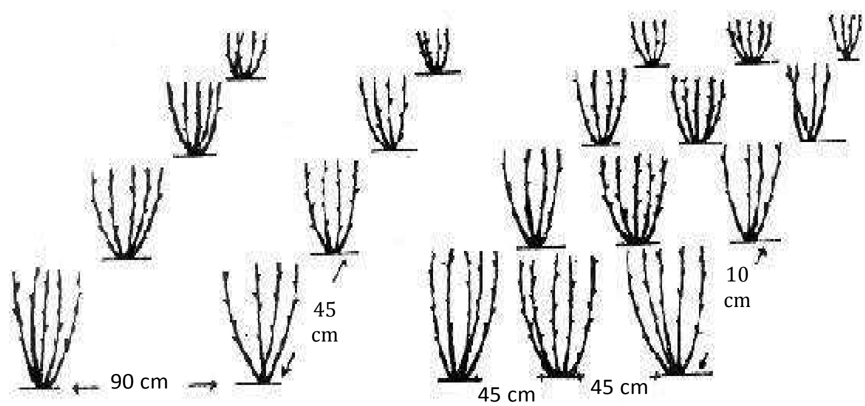


Fig. 6.7.2 Pruning Methods

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.

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 can not match to the stage of silkworms under rearing. Silk worm need a specific age leaves during different in star 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 have 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".

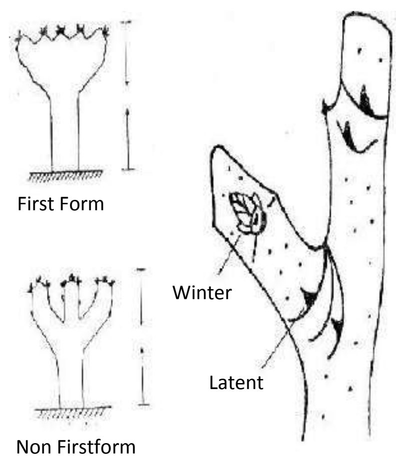
The very object of training is to get a suitable form to mulberry plants to get maximum leaf yield. This is achieved by adopting suitable pruning schedule.

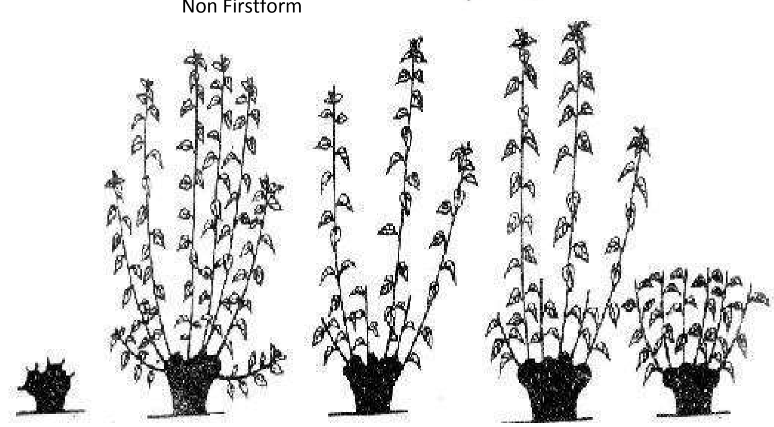
Types of Training

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 disadvantage ous 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.





1. Spring pruning for early autumn, rearing

2. Before harvest

3. After harvest for early autumn rearing

4. Before harvest for late autumn rearing

5. After harvest for late autumn rearing

Fig. 6.7.3 Fist and non-fist form

6.8 Importance of water shed

What is Watershed

Definition of Watershed:

A watershed is water catchment area, is defined as an area of land that drains water in to one location such as stream, lake or wetland. These water bodies supply our drinking water, water to agriculture and manufacturing, offer opportunities recreation (canoeing and boating) and provide habitat to numerous plants and animals. in which all water flowing into it goes to a common outlet. People and livestock are the integral part of watershed and their activities affect the productive status of watersheds and vice versa. Watershed is not simply the hydrological unit but also socio-political-ecological entity which plays crucial role in determining food, social and economical security and provides life support services to rural people.

Components of Watershed Management

- Human resource development (community development)
- Soil and land management
- Water management
- Afforestation
- Grass lands/fodder development
- Livestock management, rural energy management and
- Farm and non-farm value addition activities

This system led to overall development of the human resource and environment in the watershed.

Land and Water Conservation Practices

Soil and water conservation practices are the primary step of watershed management programme. Conservation practices can be divided into two main categories: 1) in-situ and 2) ex-situ management. Land and water conservation practices, those made within agricultural fields like construction of contour bunds, graded bunds, field bunds, terraces building, broad bed and furrow practice and other soil-moisture conservation practices, are known as in-situ management. These practices protect land degradation, improve soil health and increase soil-moisture availability and groundwater recharge.

Moreover, construction of check dam, farm pond, gully control structures, pits excavation across the stream channel is known as ex-situ management. Ex-situ watershed management practices reduce peak discharge in order to reclaim gully formation and harvest substantial amount of run of, which increases groundwater recharge and irrigation potential in watersheds.

Recommendations

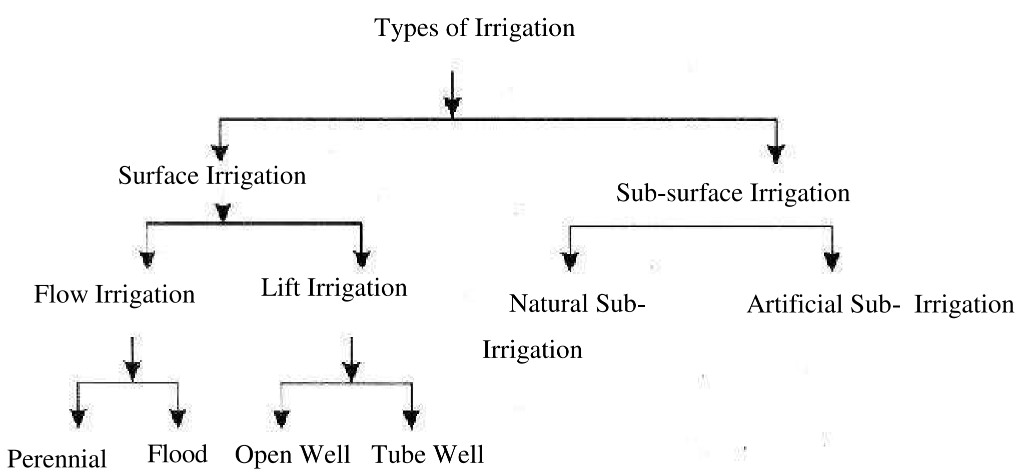
- Select watershed sites where dire need exists in terms of improving soil and water conservation, enhancing productivity and improving livelihoods.
- Adopt holistic and participatory consortium approach from the beginning i.e., from selection of watershed.
- Ensure that ground rules for operation are made clear to the community as well as consortium partners.
- Adopt knowledge-based entry point approach to build rapport with the community and ensure tangible economic benefits for the community.

The main 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



6.9 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(l.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.Flatbed method: In this method the field is divided into rectangular beds with bunds all around and channels on the sides (3.5m X 2.0 m or 4.0 x 6.0m).

1. Suitable for all types of soils.
2. No soil erosion
3. Relatively economic in water usage.
4. Low wastage of water due to runoff.
5. Irrigation is quick a. more laborious
6. Involves more wastage of space.

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

Advantages

1. More efficient from economic point of view
2. Suitable for wider and closer spacing plantation.
3. Less evaporation of water from soil surface
4. Ridges carry the system hence sufficient air is available for the roots to develop.
5. Furrows drain the excess water during rainy seasons.

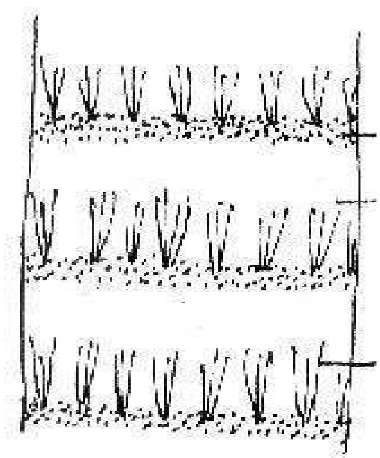


Fig. 6.9.1 Flat Bed Irrigation

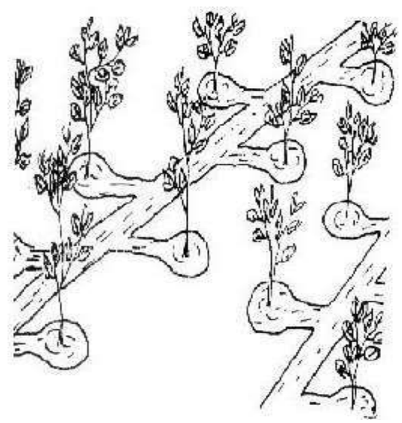


Fig. 6.9.2 Basin and Ring Method

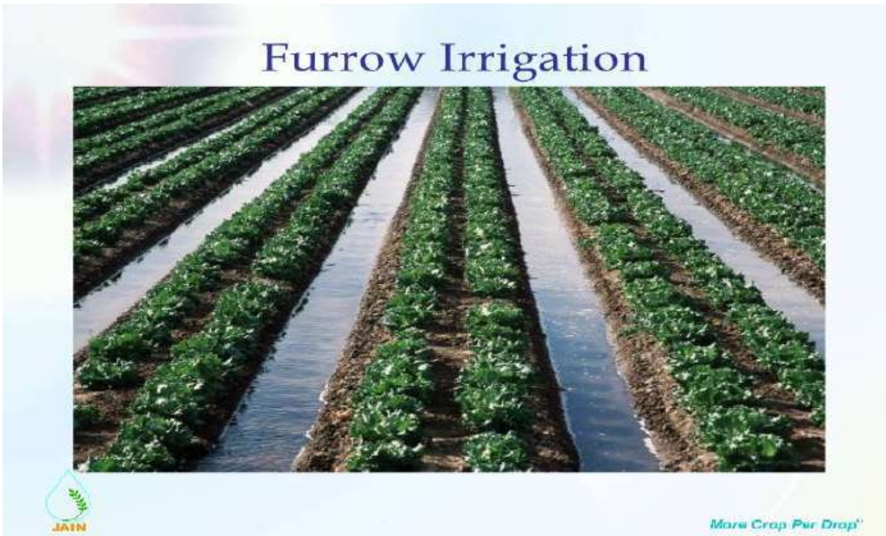


Fig. 6.9.3 Furrow Method

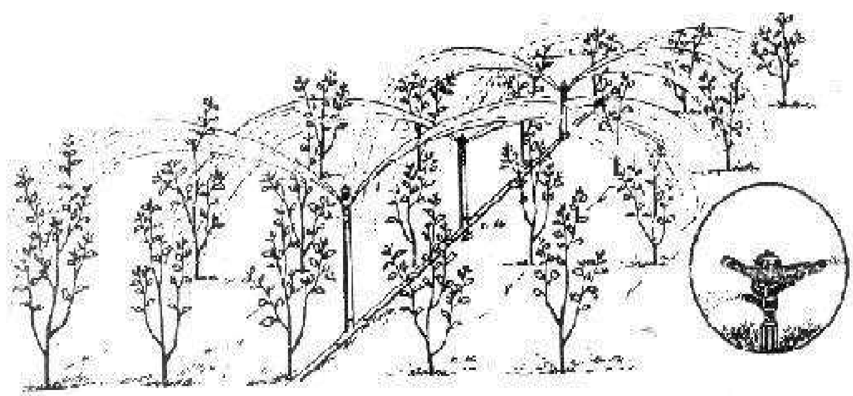


Fig. 6.9.4 Sprinkler Method

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.

4. 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.

(1) 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 1it/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

(i) **Micro Jet**: Water in this method is sprinkled 1-4 mts. long. Water discharging capacity in this method is 5-16 ltr/hr. These are recommended for large tree crops like orange, mango etc.

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

(iii) 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.

6.10 Detailed study of Drip Irrigation

Drip irrigation: Drip irrigation is a method of controlled irrigation in which water is slowly delivered to the root system of multiple plants. In this method water is either dripped onto the soil surface above the roots, or directly to the root zone. It is often a method chosen over surface irrigation because it helps to reduce water evaporation. For last recent years drip irrigation is playing major role in irrigation of mulberry gardens. This method is quite useful in not only a water saving but also its luxuriant growth. This method is suitable to all types close, wide spacing systems and even for pit methods.

Drip systems vary according to topography, size and shape of irrigated and crop type planting pattern besides, die drip equipment itself. However, a drip irrigation system basically consists of Main Line, Sub-Main, Laterals, Valves, Drippers, or Emitters, A Reiser Valve, Valve, Vacuum breakers, Pressure gauges, Water meters, Filters, Fertiliser tanks, or venturi pumps, Flash valves and pressure regulators. From the main, feeder lines are run across the field and laterals are inserted on the same. Low density polyethylene pipes are laid along the plant or tree. Rows with outlets or drippers inserted at appropriate intervals. These are designed to supply water at the desired rates (1 to 10 Litres per hour) directly to the soil.

System Components

The components of drip irrigation system can be grouped into
two major heads, viz.,

(i) Control head and

(ii) Distribution network.

Control Head

The control head of drip irrigation includes the following components.

I. Pump / Overhead Tank

Pump or an overhead tank is required to provide sufficient pressure in the system. Centrifugal Pumps are generally used for low pressure trickle systems. Instead of connecting directly to the Pump, an overhead tank having a height of about 3 metres can also be used in certain types of drip system.

II. Filters

The hazard of blocking or clogging necessitates the use of filters for efficient and trouble free operation of the drip system. The difference types of filters include:

a) Media Filter

Media Filter consists of fine gravel and sand of selected sizes placed in a pressurized tank. It is required to remove organic matter such as algae mass and other vegetative material present in the water. The media filters are available in different sizes ranging from 500 to 900 mm diameter with an output of 15 to 50 Cu.mt. respectively.

b) Hydro-cyclone or Centrifugal Filters or San Separators

If the irrigation water is having more sand, hydro-cyclone type filters are required to remove the sand; it is also known was vortex sand separator. Hydro-cyclones must be followed by a screen filter as a safeguard.

c) Screen Filters

The screen filter is fitted in series with the gravel filter to further remove the solid impurities like fine sand and dust from the water. In general, the screen filter consists of a single or double perforated cylinder placed in a plastic or metallic container for removing the impurities. Generally, 100 to 200 mesh screens are used in this type of filters. It must be cleaned and inspected periodically for satisfactory operation of any drip system.

III. Fertilizer Applicators / Fertigation

The direct application of fertilizer through drip irrigation has\ increased the efficient use of fertilizer along with saving in labour and money. Application of fertilizer into pressurised irrigation system is done by either a by-pass pressure tank, or by venture pump or direct injection system.

Distribution Network

The distribution network mainly constitutes main line, sub main line, sub-submain and laterals with dripper and other accessories.

I. Main Line, Sub Main Line

Generally Rigid PVC and High Density Polyethelene (HDPE) pipes are used as main line. Pipes of 65 mm diameter and above with a pressure rating of 4 to 6 Kg/Sq.cm, are recommended for main pipes. These pipes laid underground, offer a long life of more than 20 years. For sub-main pipes, Rigid PVC, HDPE or LDPF (Low Density Polyethylene) are recommended. Pipes having a outer diameter ranging from 32 mm to 75 mm with a pressure rating of 2.5 Kg/Sq.cm, are used as sub-mains. These pipes may be laid above the ground or underground.

II. Laterals

The laterals / drip lines are normally manufactured from LDPE. These pipes are generally laid above the ground. Recently a better material than the presently used LDPE namely Linear Low Density Polyethylene (LLDPE) is being used. Generally, pipes having 10, 12, 16 and 20 mm internal diameter with wall thickness varying from 1 to 3 mm are used in drip system.

III. Polytype

It is made with LLDPE with super speed extrusion for high pressures and stress and crack resistance.

Drippers / Emitters

Drippers function as energy dissipators, reducing the inlet pressure head (0.5 to 1.5 atmosphere) to zero atmosphere at the outlet. These drippers are generally manufactured from poly-propelene materials.

a) Inline Drippers

The inline drippers are fixed along with the line ie., the pipe is cut and dripper is fixed in between the cut ends, such that it makes a continuous row after fixing the dripper. The inline drippers have generally a simple thread type or labyrinth type flow path. With the labyrinth type flow path, it is possible to have larger cross section area and tarbulent flow of water to prevent clogging of dripper. The inline drippers are available with discharge of 2, 3, 4, 8 litres/hr. at 1 atm. pressure. These drippers can be fixed in 10 to 13 mm internal diameter pipes.

b) Online Drippers

The on-line drippers are fixed on the lateral by punching suitable size holes in the pipe. These drippers can be classified into simple or non-pressure compensating type and pressure compensating type.

Fig 6.10.1 Drip irrigation

Advantages of drip irrigation:

1. Conservation of water by preventing the evaporation loss on irrigation channels.
2. Saving of man power required for irrigation.
3. Control of weeds & hence high yield.
4. Uniform irrigation to the entire garden at a time.
5. Possibility of giving fertilizers through drip system exactly to the plant near the root zone. This will not only reduce the labour cost, but also prevents the wastage of fertilizers.
6. High Wind velocity: in places where wind velocity is very high i.e., more than 15-20 Kms/hr, water evaporation will be very high & hence, drip irrigation will have an added advantage.

S No	Particulars	Flood irrigation	Drip irrigation
1	Water required for each irrigation	1.55 lakh litres or 1.5 acre inch	0.22 lakh litres i.e., 2 litres/ plant/ day

2	Irrigation interval	Once in 5 days	1 hour / day
3	No.of irrigations per crop period (70 days)	70/5 = 14	70/1= 70
4	Total water required (lit)	21.7 lakh lit	15.4 lakh litres (if spacing is 2 X 2)
5	Water saving by drip	21.7 – 15.4 = 6.3 lakh litres	= 29 %
6	Percentage of water saving =	$\frac{\text{Water saved by drip}}{\text{Water used in flood}}$	X 100
Water saving in 2 x2 Plantation = 29 % Water saving in 2 x3 Plantation = 53 % Water saving in paired row system = 61 % Water saving in 3 x 3 Plantation = 69 %			

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 35X35X35cm at a spacing of 90X90cm, 10 ton of organic manure/ha is recommended.
- Under irrigated conditions rows are made 60cm apart, cuttings 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 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 synchronise 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 fist form?
5. What is Training?
6. What is Irrigation?
7. Define watershed.

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 equipment 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) HighCut.

Numerical Questions

1. Identify the different weeds. Collected it and prepare her barium.

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.

UNIT 7

Manures and Fertilizers

Structure

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

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Plants need several kinds of nutrients for their normal healthy growth, which are obtained from air, water and soil. The environment is an out door chemical factory where the plant get different energy and nutrients from sunlight, soil and water and convert them in to 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 lost by volatilization and de nitrification. 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 in to bulk organic manures and concentrated organic manures based on concentration of the nutrients.

Plants need 16 elements for their growth and completion of lifecycle. 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 CO_2 and assimilated in photo synthesis. Except C, H, O others are called mineral elements. Above all, the primary plant food elements i.e., nitrogen, phosphorus, potassium are obsorbed 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 Organic 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. 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.

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
    - Gober gas plant manure
    - Silk worm litter
  - Concentrated Organic Manures
    - Oil Cakes
    - Blood meal
    - Meat Meal
    - Fish Meal
    - Horn &Hoof Meal
    - Bone Meal
  - Green Manures
    - Bio fertilizers
    - Vermi Compost
- In-Organic Manures
  - 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_2fertilizer.
5. Plant parasitic nematodes and fungi are controlled to some extent by altering the balance of microorganisms in the soil.
6. food for soil microorganisms. This increases activity of microbes which in turn help convert unavailable plant nutrients in to available forms.

2. Farmyard Manure

It refers to the decomposed mixture of dung 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 farm yard manure contains 0.5 percent N, 0.2percent P_2O_5 and 0.5 percent K_2 O. Thus, it is one of the most important agricultural byproducts, 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 notconfined to the season of application but persists over a number of years. The micro and macro nutrients fertile 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_2O_5,K_2O) 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 meter 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 7.1: Micro Nutrients in Animal Dung – organic Fertilizers Manure/ Fertilizer.

Manure/Fertilizer	**Dry matter in ppm**			
	B	**Mn**	**Cu**	**Zn**
Nitro Chalk	**0**	**24**	**22**	**15**
Sodium Nitrate	0	08	03	**01**
Ammonium sulphate	06	06	02	0
	11	11	04	150
Super Phosphate				
Potassium sulphate	04	**06**	**04**	**02**
Potassium chloride	14	**08**	**03**	**03**
Cow dung	20	**410**	**62**	**120**

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

Table: 7.2

Excreta		**Percentage of**		
		N	**P2O5**	**K2O**
Cows and Bullocks	Dung	0.40	0.20	0.10
	Urine	1.00	Trace	1.35
Sheep and goats	Dung	0.75	0.50	0.45
	Urine	1.35	0.50	2.10
Horses	Dung	0.55	0.30	0.40
	Urine	1.35	Trace	1.25
pigs	Dung	0.55	0.50	0.40
	Urine	0.40	0.10	0.45

From the point of soil fertility, the excretes of various farm animals is important for the supply of N, P_2O_5, K_2O 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, 10-14Kg 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, every10 tones of FYM contain 50Kg nitrogen, 20Kg phosphorus, 50Kgpotash.

Partially rotten farm yard 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% of nitrogen, 60-70% of phosphorous and 70% of potassium are available to the first crop. For mulberry 10 tons of farmyard manure for the rain fed crop and 20 tons for irrigated crop are recommended for one hectare of mulberry per year.

Compost

It is a mass of rotted organic matter made from waste. This process is to decompose plant residues 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 in to 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 an aerobic. The residues usually used in compost have a carbon nitrogen ratio of 40:1 which is reduced to 10:12 after compositing. 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_2O_5 and 0.5 percent K_2O. The nutrient value of farm compost can be increased by application of super phosphate or rock phosphate at –10kg/ton of raw material at the initial stage of filling the compost pit. The compost made from tow refuses like night soil, street sweeping sand dustbin refuse is called town compost. It contains 1.4 percent N, 1 percent P_2 $O\text{-}_{5\text{-}}$ and 1.4 percent K_2 O. In the village compost, the amount of nitrogen varies from 0.4-0.8 percent, P_2 $O\text{-}_{5\text{-}}$ 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.

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 hand 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 40-50 percent of saw dust to night soil yields a dry, acidic poudrette which contain 2-3 percent nitrogen.

Poultry Manure

It is of the best manure. The excreta of birds ferment very quickly, If left exposed 50% 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_2O_5 and 1.4 percent K_2O. This manure has to be applied directly to the field.

Biofertilizer: (*Azotobacter crococcum):* Capable of supplying "N" to plants through biological nitrogen fixation, and hence 50 % of "N" dose can be cut down without any loss of leaf yield. Hence 50 % savings on the cost of "N" fertilizer.

Dosage: 4 kg / ha / crop with 200 kg powdered FYM i.e, 1.6 kg / acre / crop with 80 kg powdered FYM. Make furrows of 1/2 ft depth near the plant rows, apply the biofertilizer, cover with soil and irrigate immediately.

Note: chemical fertilizer should neither be mixed with biofertilizer nor applied simultaneously. There must be a minimum gap of 7-10 days between the application of biofertilizer and chemical fertilizer. It may be used for all the 5 crops in a year. However maintenance of continuous soil moisture is necessary for best results.

Seri-azo and Seri-phos biofertilizer: Seri-azo contains Nitrogen fixing bacteria, and Seri-phos contains phosphorus solubilizing bacteria. By using the combination of these two, "N" and "P" fertilizer doses can be reduced by 50 %. ***However, it should be ensured that, the organic carbon levels of the soil must be more than 0.65, otherwise the results will be negative in terms of leaf quality and yield.***

Method of application of Seri-phos: Mix 1.6 kg of Seri-azo and 0.4 kgs of Seri-phos with 80 kgs of powdered FYM and apply to 1 acre of mulberry garden for every crop in furrows of 1/2ft depth preferably adjacent to the root zone, cover with soil and irrigate the garden.

Green Manures for Mulching:

Fig. 7.1 Mulberry garden with green manure plants grown in between rows

Leguminous crops like Sunhemp (*Crotalaria juncea*), Dhaincha (*Sesbania aculata*), Cowpea, horsegram, Cluster bean etc., produce high green manure content within a short duration. One day prior to sowing, soak the seed in water and broadcast @ 8 — 10 kg /acre. Mulch the plants before flowering (takes 45 days) and irrigate thoroughly.

Note: Instead of mulching, the green manure plants can be cut at flowering stage and rich compost can also be prepared.

Note: for better results, treat the seed with rhizobium culture before **b**roadcasting. To prepare rhizobium culture, dissolve 50g of jaggery in 1 litre of water, boil it for 10 minutes and cool. To this cool jaggery solution add 200g of Rhizobium powder and mix the contents thoroughly. Add this preparation to 8-10 kgs of seed, mix thoroughly before sowing.

Green manure contains 6.2 kg Nitrogen, 1.5 kg Phosphorus and 4.6 kg potash/ MT. By this method about 50 kg nitrogen, 12 kg of phosphorus and 40 kg potash can be made available to the soil/acre/year.

Hence, application of nitrogen fertilizers can be cut down for every crop to a tune of 25 to 50%. Similarly, P & K fertilizers can be reduced by 25% only when compost & green manures are regularly applied.

Advantages: organic carbon and soil microbial activity is enhanced. Water holding capacity of the soil is improved leading to high leaf yield. Expenditure on fertilizers can be minimized. weeds are reduced by 60-70%.

Mulberry - Inter crops :

Recommended inter crops: maximum 90 days, preferably 70 days duration crops are recommended. All legumes like horse gram, black gram, beans, soya beans etc., **and** cow pea, turmeric, coriander, zinger, ground nut etc.

Spinach (Paalak): It has a very short growth period and has good market value. It is one of the best inter crops for mulberry. Beans: 3MT/ha yield and gives additional income. Harvest can be started 45 days onwards along with mulberry.

Note: Solanaceae's plants (tomato, potato, brinjal & chilly) are not recommended as inter crops, because they are prone to root knot disease (Meloidogyne incognita) which affects mulberry. Beans crop is also known to spread root knot in mulberry.

Table 7.3:

Fertility status of organic manures:

Nutrient	FYM	Vermi-compost	Compost	Green manure
N %	0.4	1.93	1.78	0.62
P %	0.3	0.75	0.62	0.15
K %	0.4	1.3	0.76	0.46

Note:

- Vermicompost despite having high nutrient value, forms an excellent base for the multiplication of soil microbes which helps in Nitrogen fixation. It is also a rich source of "VAM" which helps in "P" uptake by the plant.
- NPK values of compost and vermi compost may vary widely basing on the type of materials used and the method of composting.
- Studies indicate that, FYM should not be totally substituted by any other organic manure. At least 25% of FYM component should be maintained when other organic manures are used.

Tank silt: Contains micro and macro nutrients and rich in organic matter. It improves fertility and water holding capacity of the soil.

Note: In some cases, the tank silt may have abnormal P^H. Hence, as a precautionary measure, P^H may be examined before application.

Press mud: A bye-product of sugarcane industry containing 8% of phosphate and hence a rich source of 'P'also contains Calcium, Organic matter, NPK and some trace elements. Rreclaims alkali soils & reduces soil P^H from 8.5 to 7.6. Apply 16 MT/acre/Y in two splits, divide garden into sub-plots broadcast the press mud with deep ploughing and flood irrigation.

7.3 Types of Fertilizers, Application methods and schedules

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, micro and macronutrients. 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.

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 wrinkled. 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 based on the chemical form.
They are nitrate, ammonium nitrate, ammonium and amide fertilizers.

Nitrate	- Sodium nitrate, Calcium nitrate
Ammonium	-Ammonium sulphate, Phosphate Chloride. Ammonium
Nitrate	- Ammonium nitrate, Calcium, Ammonium Nitrate, Ammonium sulphate.
Amide	- Urea, Calcium cyanamide.

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 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.

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 in laying down the primordial for their productive 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 cause 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_2O_5). Rock phosphate is the basis for this fertilizer.

These are classified into three groups depending on the form in which Ortho phosphoric 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.

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 potassium fertilizers are applied. Sandy soils are known to respond to potash.

Potassium does not enter in to 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 counter acts 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 longtime.

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 K_2O in addition to 17.5 percent sulphur. It dissolves in water and immediately available to crop.

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 soils 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.

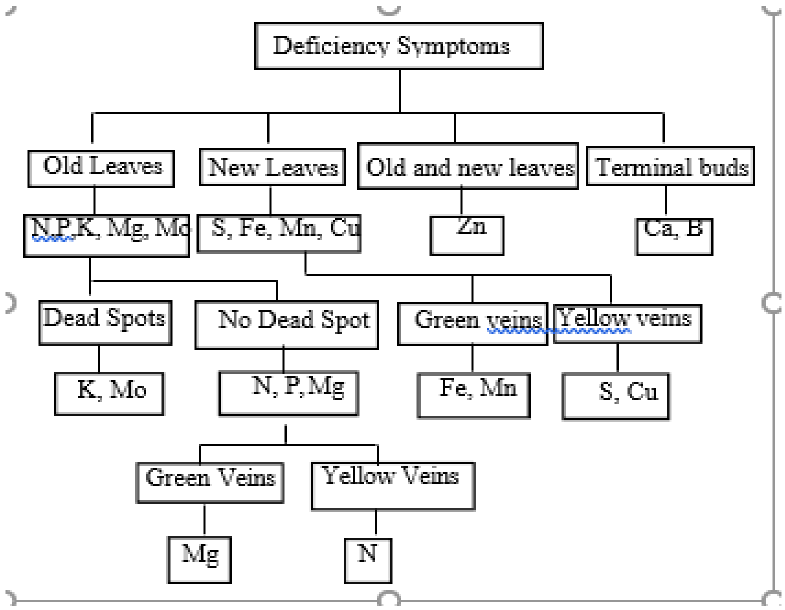


Table 7.4 Identification of Deficiency Symptoms

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 7.5

Ca, Mg and S contents of different fertilizer materials

Component	Ca	Mg	S	Others	
Calcium Nitrate	19.4	-	-	-	
Gypsum	29.2	-	18.6	-	
Rock phosphate	33.1	-	-	-	(P_2O_5)
Single super phosphate	19.5	-	12.5	-	(P_2O_5)
Triple superphosphate	14.0	-	1.0	25.2	(P_2O_5)
Epsom salt	-	9.6	13.0	16.0	
Potassium magnesium	-	11.1	22.3	43.5	(K_2O)
Potassium sulphate	-	-	17.5		(K_2O)
Ammonium sulphate	-		24.2	31	(N)
Ammonium sulphate nitrate	-	-	12.1	48	(N)
Basic slag	-	-	3.0	21	(P_2O_5)
Copper sulphate	-	-	11.4	26	(Cu)
Ferrous ammonium sulphate	-	-	16.0	15.6	(N) 16(Fe)
Ferrous sulphur	-	-	18.8	21	(Fe)
Elemental sulphur	-	-	100.0	6	
Urea-gypsum	4.6	-	0.6	36.8	(N)
Urea - sulphur	-	-	10.0	40	(N)
Zinc sulphate	-	-	17.8	36.4	(Zn)

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.

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 1OOkg 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-hygroscopic 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.

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.

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

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 counter acting the bad effect of poor aeration. In manganese deficiency the principal veins and small veins are green.The inter veinal 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.

Boron: 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.

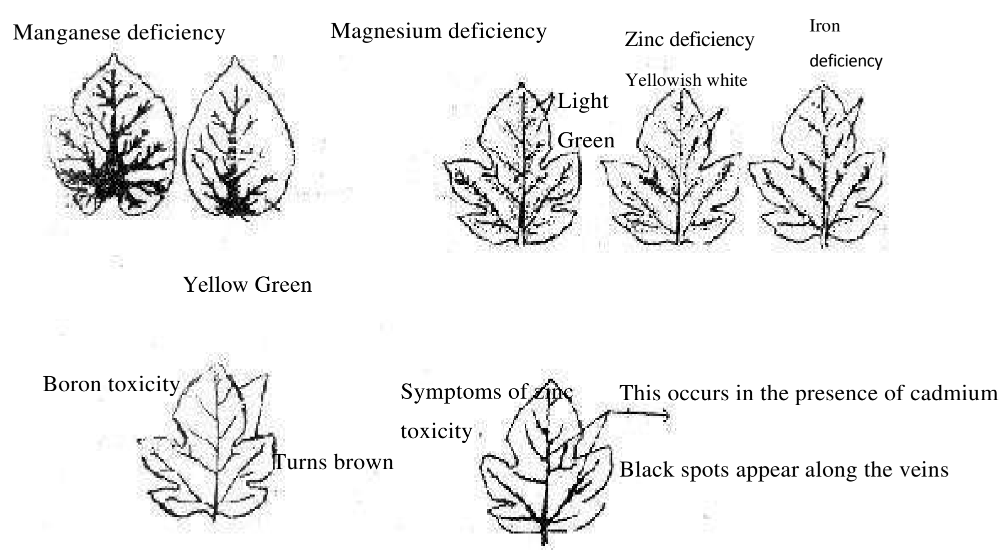


Fig 7.2 Deficiency Symptoms

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

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 with stand 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.

Zinc deficiency:

Symptoms: Chlorosis, Scorch yellow & brown colouration. Sometimes dark veins.

Treatment: Spray 1 % Zn SO_4 (10 g /litre) 15-25 days after pruning apply ZnSO4 @ 10 kg/ Ac/ year with 'N' fertilizer.

Note: $ZnSO_4$ should not be mixed with Single Super phosphate. because, it get fixed in the soil and will not be available to the plants.

Table.7.6 Micro nutrient contents in Organic Manures(in ppm)

Manure	Zinc	Copper	Manganese	Iron
Organic manure	120	62	410	-
Cow dung	210	61	150	-
Goat dung	2570	1925	6420	-
Poultry manure	70	82	191	1280
Rice straw	20	-	340	280
Pig manure	198	12	168	1600

.

Table 7.7 Range of micro nutrients for normal growth

Trace Elements	Concentration in ppm
Fe (Iron)	0.5-5.0
Mn (Manganese)	0.1-0.5
B (Boron)	0.1-1.0
Zn(Zinc)	0.02-2.0
Cu(Copper)	0.01-0.05
Mo (Molybdenum)	0.01-0.05

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 (37molybdenum) liquid can be sprayed on plants. It can also be mixed with complex fertilizers.

Micronutrients:

Calcium, Magnesium, Zinc and Iron are important Micronutrients. They play important role in producing quality leaf. Optimal micronutrient levels in mulberry leaf in turn stimulate metabolic activities in silkworms leading to improvement in cocoon yield, silk content and fecundity.

Table:7.8 Some micronutrient products and growth stimulants:

Zn SO4 (with micro- nutrients) (36% Zn)	➢ 1% foliar spray (10 g / litre) 15-25 days after pruning. **Or** 10 kg/Ac/Year soil application along with 'N' fertilizer. **Note**: *Zinc sulphate should not be mixed with single super phosphate, because, it gets fixed in the soil and will not be available to the plants.*	
Ferrous SO_4 (19% Fe)	➢ 0.5 % foliar spray (5 g / litre)	
Poshan (Contains both micro and macro nutrients & also growth promoter)	➢ 0.7 % foliar spray (7m1 / litre)	
4.Seriboost (Tricontinol—micronutrient mixture)	2.5 ml / litre i.e., 1.5 litres / 600 litres/ ha i.e., 500 ml / 200 litres	• 1st dose : 25 days after pruning. • 2m1 dose: 7 days after
5. Vipul (Tricontinol-CF) (growth promoter)	0.21 ml / litre i.e., 125 ml / 600 litres / ha i.e., 50 ml / 240 litres/Acre	1st dose : 15 days after pruning. • 2nd dose :15 days after l'dose

Poshan:

"Poshan" is a Multi-nutrient formulation developed by CSR&TI, Mysore, mainly to rectify the problems associated with the deficiency of multi nutrients (Macro and micro nutrients) in mulberry plants.

Nutrient deficiency in the soil results in chlorosis and stunted growth of plants. As a result, the leaf quality and yield will be seriously affected. In such cases, foliar application of “Poshan” can effectively control the deficiencies and contribute to the uniform growth of the garden despite improving leaf quality.**”Poshan”** is an ideal formulation of both micro and macro nutrients and includes a growth promoter as well. Hence, it is effective even for general use on regular basis to improve leaf quality and yield.

An improvement of leaf yield up to 30% in case of nutrient deficient gardens and about 15% in case of normal gardens can be achieved by this method.

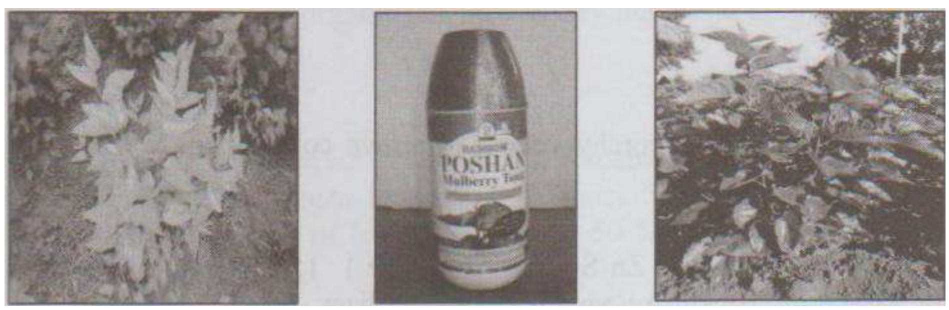


Fig: 7.3 Plants supplied with Poshan

Method of application: Mix "Poshan" @ 7m1 / litre and spray to mulberry garden between 20 to 25 days after pruning. A single spray of 1 litre of poshan in 140 litres of water is sufficient for 1 acre of mulberry garden.

"Poshan" is completely non- toxic to silkworms, and hence can be safely used without imposing any contamination problems to the neighboring mulberry gardens silkworm rearings within the vicinity.

Note: For optimal results, Spraying of "Poshan" should be carried out preferably during morning hours between 8 to 11 a.m.

Seriboost:

1. It is a mixture of micronutrients (Boron, molybdenum, copper, iron, zinc. manganese) & growth promoter (n-Tricontinol).
2. Seri boost may be used as a foliar spray @ 2.5 ml/lit. First spray is given 25 days after pruning or leaf harvest, preferably followed by a 2nd spray 1 week after the first spray.

3. It is compatible with the generally used pesticides (can be mixed with pesticide solutions)
4. It increases the absorption of macronutrients (NPK) and micronutrients sulphur, calcium & magnesium) from the soil by the plants.
5. It improves the leaf quality and yield to a significant extent.
6. It is non-toxic to silkworms.

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 rainfed 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 300 kg of nitrogen, 120 kg of phosphorus and 120 kg of potash per hectare of irrigated farm. Rainfed mulberry is recommended 100kg of nitrogen, 50kg of phosphorus, 50kg of potash per hectare.

Table: 7.9

Schedule	**Irrigated N-P-K**	**Rainfed N-P-K**
a. Recommended dose kg/ha per acre	300:120:120 120:48:48	100:50:50 40:20:12
b. To be applied in	Five spilt doses one dose after each crop	Two doses one dose after pruning and one after first crop
c. Quantity of nutrients for each dose (per acre)	I dose 24:24:24 II dose 24:0:0 III dose 24:24:24 IV dose 24:0:0 V dose 24:0:0 Total 120:48:48	I dose 20:20:20 II dose 20:0:0 (After the rains when there is sufficient soil moisture) Total 40:20;20
d.Quantity and type of fertilizer to be applied to one acre to provide the above nutrients.	1. 15:15:15(Suphala) 160 kg or 17:17:17 (Vijay) 141 Kg	15:15:15(Supha)133Kg or 17:17:17(Vijay)118 Kg
	2. Urea 53 Kg or Ammonium sulphate 114kg	Urea 45Kg or Ammon sulphate100 kg
	3.Urea 53 Kg or Ammonium Sulphate 114 Kg	
	4. Urea 53 Kg or Ammon Sulphate 114 Kg	

7.4 Detailed study of 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 micro nutrients, such as nitrogen, phosphorus, magnesium, zinc and calcium in simple forms, so that the plant root system can readily absorb them.

Eudrilus eugeniae*; *Eisenia foetida*- and *Perionyx excavats earthworms are used in vermin compost preparation.

1. Vermiculture is the fastest method of converting waste organic matter into a fertile compost.
2. Each earthworm feeds 4 —5 times of its own weight of material every day.
3. Vermi compost forms an excellent base for multiplication of soil microbes.
4. Increased microbial population helps "N" fixation and increases the available P & K and uptake of "K".
5. Rich in VAM (Vesicular Arbuscular Mycorrhiza) propagules which are colonized in root cells and greatly enhance the absorptive surface area of root system; and nourish the plant with "P" in particular and other micro nutrients in general.
6. Excretions of earthworms also contain several growth promoting substances.
7. Enhances the humus formation.
8. Earthworms will improve soil texture, aeration, nutrient status and activates local earthworm population in soil.
9. Vermi compost has a Very high nutrient value (N: 1.93%; P: 0.75% & K: 1.3%) as compared to FYM and compost.
10. From 1acre mulberry garden 5-8 Metric tons of waste material can be obtained through rearings & other sources, which can be effectively converted through vermiculture or composting.

Species: 2000 species in the world — 500 species of earthworms in India are available. Most of the species undergo diapause. Only after arrival of rainy season they will be active. To avoid this problem, and to maintain the culture throughout the year 3 species which do not undergo diapause are used. They are ***Eudrilus eugeniae, Eisenia foetida, and Perionyx excavatus.*** Any one of these species or the combination of all the three species may be used. These species will be active throughout the year in general and be very active during June — December in particular.

Climate: 20-30 °C Temp and 6.8-7.5 P^H; moisture :40-50 %; Best season : June —December.

Spacing: 2000 worms / Sq mt (3 ft thick bed) i.e.., 6000 worms / 12 x 3 x 3 ft bed or 4300 worms / 8 x 3 x 3 bed.

Tank: 4 Nos of Vermiculture tanks of size 8'x3' x3' are constructed above ground level. Each tank will have an outlet of 1or 2 inches diameter at the bottom to let out any excess water. In advanced stage vermi wash can be collected through these outlets.

Method:

1.Partially decompose all the waste material (40 — 50 % Moisture) for 15 — 20 days; during which material is thoroughly mixed frequently.

2.Release the earthworms on the beds and cover.

3.Maintain 40-50% bed moisture by watering the beds every 3-4 days.

4.Allow the earthworms to feed on this partially decomposed material for about 30 to 40 days. During this period earthworms excrete vermi castings which have high fertility values.

5.Extract the whole material and dump it in the form of a mound and allow for 1/ hours in shade.

6.Mesh the contents in 3 mm mesh and separate the castings and earthworms which may be released on the beds as soon as possible. If the earthworm population in tanks is good, instead of meshing, manual separation of earthworms can be practiced to save time.

7.Shade dry the castings partially and use it. It is always better to use the vermi compost afresh.

Dosage and application:

Vermi-compost is almost 5 times richer in NPK over FYM. Apply it in furrows adjacent to plant rows. Don't mix chemical fertilizer. Fertilizer can be applied after / before 10 —15 days.

- 10 MT FYM + 3 MT Vermicompost /ha/Y in 2 splits (1st and 3rd crops) & fertilizers as usual. Or
- 10 MT of vermi compost alone per year in 2 splits (1st and **2nd** crops) & cut down 50% NPK.

"**Note:** As per the studies conducted, it is evinced that, the application of FYM 4) could not be totally substituted with any other manures. Hence, combination of vermi compost & FYM is preferred over the vermi compost alone to sustain soil Health in the long run.

Efficiency: 8 x 3 x 3 ft size: In each tank 0.5 MT x 5 harvests = 2.25 MT / year. Therefore in four tanks 9.0 MT / year can be extracted. Efficiency: 1 MT raw -material **4** 0.75 MT vermi compost . Hence, the efficiency = 75%.

Precautions:

1). Water stagnation in the tank leads to Anaerobiosis→change of P^H →mortality of worms. Therefore 40 — 50 % moisture is optimal (when material is squeezed, water should not drip)

2). Holes may be made on the vermi beds from the surface to the bottom using a long stick here and there to allow aeration. Worms should not be released in fresh material, as this will release excess heat and destroys earthworm population.

Fig 7.4 Earthworms in compost

Fig 7.5 Vermi comost pits under shade

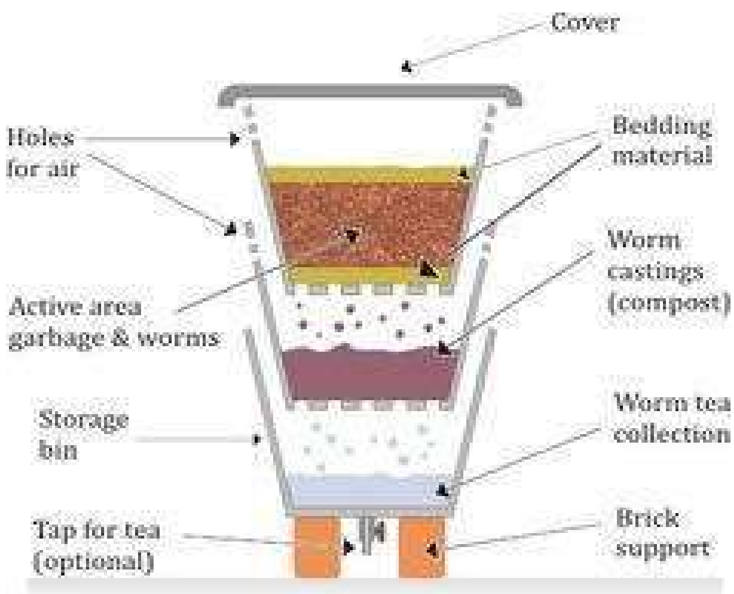


Fig 7.6 Different layers of vermi compost pit

Fig 7.7 Vermi castings

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.
- Farmyard manure is the decomposed mixture of dung and urine of animals along with left-over/refuse which contains good amounts (N, 0.2% P_2O_5, 0.5% K_2O) 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 perming is the better way to utilize urine and fecal matter.
- Gober 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.
- In organic 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 lavono 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, lavono, iron sulphate arc

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, Azospirillium, 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 lose 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 and 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 micronutrients.
12. What is Poshan?
13. What is Seri boost?
14. What are primary and secondary nutrients?
15. What are bio fertilizers?
16. What is vermi compost?
17. What are the methods of application of manures/fertilizers?
18. What are the methods of storing fertilizer?
19. What are the fertilizer requirements of mulberry?
20. Name some of the sources for micronutrients.

Essay questions

1. Write a detail note on farmyard manure.
2. Write a brief note on concentrated organic manures.
3. Write about green manures.
4. Write short notes on

a. Compost b. Poultry manure c. Bio-fertilizer

5. Write about bulky organic manures.
6. Write short notes on

a. Sewage & Sludge b. Oil cakes c. Sheep & Goat manure

7. Write a detail note on macro nutrients.
8. Write a brief note about micro nutrients.
9. Comment on complex fertilizers.
10. What is bio fertilizers? Write about different bio-fertilzers and its importace.
11. Write a detail account on vermi compost preparation.
12. Write short notes on

a. Storing of manures b. Chlorine c. Fertilizer dose

13. Write short notes on

a. Fertilizer application methods b. Application schedules

14. Write a brief 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 preserve chemical fertilizers
- Identify the different symptoms of Micronutrients
- Adopt the balanced use of fertilizers in splitting doses.

UNIT 8

Nutritive Values of Mulberry Leaf

1. Introduction
2. Bye Products of Mulberry
3. Medicinal and other use of Mulberry
4. Contents of Mulberry leaf

8.1 Introduction

The Mulberry leaf is the exclusive food of the silk worm *Bombyx mori(L).* The growth of the silk worm very much depends on the quality of leaves fed to them. The leaf quality is influenced by various factors such as soil, pruning, fertilizer, rain fall, irrigation, etc., With those conditions mulberry grows luxuriously with rich contents of proteins and carbohydrates. Further the leaves are also succulent due to high nutrient content. These types of leaves are edible for silkworms for better growth and to produce good cocoons, leaves of Mulberry grown on loamy soil contain more water, protein and less carbohydrate and fibre, Further the leaves mature slowly.

8.2 By – products of mulberry

Like other crops sericulture also leaves some bye-products at every level, which can be utilized in many ways. We can proudly say that "Nothing is waste in Sericulture". Further this aspect also gives lot of scope for self-employment where many persons are involved in processing, collecting and transporting of bye-products.

Uses of Mulberry plant:

The amount of Nitrogen, Phosphorus and Potassium present in the left over mulberry leaf is 3.1, 0.55 and 1.5 percentage respectively. The mulberry plant which is the main stay of silk worm has several uses. Some of these are –

(i) The fruits are edible and rich in C Vitamin, can also be used in the manufacture of Jam and in Europe mulberry is exclusively grown for its fruits from which wine is made.

(ii) The stem in the trees is white in colour, soft and flexible. It is in great demand in the manufacture of sports goods specially cricket bats. Many agricultural implements can also be fashioned out of the stem. The wood pulp of the stem is a good raw material for the manufacture of quality paper.

(iii) Mulberry leaves constitute a good cattle feed. It is known that this feed increases the milk yield.

(iv) Various parts of the plant body have a high medicinal value and are used in the Ayurvedic system of medicine.

a. The fruit is aromatic, cooling, laxative, removes thirst and good in the treatment of fevers.
b. Bark is anthelmintic and purgative.
c. Leaves in the form of decoction are used to gargle in the treatment of inflammation of the vocal cards.

d. Roots are anthelmintic and astringent (acts as a binding agent) and useful in the treatment of diahroea.
e. There are four species of mulberry – *Morus acedosa, M.alba, M. indica* and *M. nigra.* All these species are of medicinal value.

8.3 Medicinal and other uses of mulberry

Mulberry Leaves

Mulberry leaves are rich in calcium, phosphorus, magnesium, vitamins like B, C and K. They also contain antioxidants particularly the anthocyanins and the flavonoids quercetin and kaempferol. The leaves contain 18 amino acids viz ; phenylalanine, leucine, valine, tyrosine, proline, alanine, glutamic acid, glycine, serine, arginine, aspartic acid, cystine, threonine, sarcosine, gamma-amino-butyric acid, pipecolic acid, and 5-hydroxy pipecolic acid. The leaves are also a good source of ascorbic acid. The medicinal properties of mulberry leaf are recognized for its diuretic, blood sugar and blood pressure reducing effects. The leaf extract of white mulberry (*Morus alba*) has been studied against the Indian *Daboia russelii* venom induced local and systemic effects. The extract completely abolished the *in vitro* hyaluronolytic and proteolytic activities of the snake venom (Chandrashekara *et al.*, 2009) [2]. New pharmacological benefits of mulberry leaf against serious diseases like Alzheimer's disease, atherosclerosis, hyperlipidemia etc have been reported.

Against Alzheimer's disease, hyperlipidemia and Prevention of Atherosclerosis

Lyengar in 2007 [11], suggested that mulberry extract provide viable treatment to Alzheimer's disease through inhibition of amyloid beta- peptide (1-42) fibril formation and attenuation of neurotoxicity induced by amyloid beta- peptide and further confirm that mulberry leaf contains anti-oxidative substance that helps to prevent atherosclerosis and some lavonoids that are effective in controlling hyperlipidemia.

Mulberry tea

A special tea called mulberry tea is made from mulberry leaves. It is caffeine free. The tea is known to improve the function of liver and kidney and sharpen the hearing and brighten the eyes. Further more it relieves colds, coughs, throat infections, supposed to prevent oxidation of cholesterol consequently keeping the arteries free of fat deposits and hence hardening of arteries. In Iran, dried mulberries are used as a sweetener in black tea. After a sip of tea, dried mulberry fruits are eaten to sweeten the mouth

Mulberry tea brands

Fig 8.1 Mulberry tea brands

Mulberry fruits

Anti-obesity mulberry fruit drink

A super fruit drink, full of antioxidants is prepared from pure fresh mulberry fruits. It is a good source of resveratrol which is beneficial for heart health. The drink suppresses the appetite, which is why it has been reported as a useful drink against obesity (Fairjuice, 2008) [4].

Mulberry fruit powder

Mulberry fruit powder promotes healthy cholesterol and controls carbohydrate digestion in the human body. It is believed to prevent heart disease, cancer and many other serious diseases. It works as an anti-mutagen which can inhibit the mutation of healthy normal cells into cancerous cells.

Mulberry fruit wines

Mulberry wine is obtained from Over-ripened and sour mulberry fruits. The wine has a sweet taste. It has been found that a glass of mulberry wine a day helps get rid of oxides and fecal residue from the body which can help make the body slim. The wine made by immersing the mulberry in grape wine works as medicine for weakness after diseases that can also be used to tonify masculine vitality. Furthermore it is believed that small dose of the wine protects against heart and stomach diseases. In Europe mulberry fruit wine is very popular as a lady's drink.

Fruit pigments as dietary modulators

Mulberry fruits contain anthocyanins like cyaniding-3-rutinoside and cyaniding-3- glucoside. These pigments hold potential for use as dietary modulators, besides this they are easily extractable and incorporated into the aqueous food systems, so, they are also used as natural food colorant.

Mulberry fruits in pharmaceutical industry

The mulberry fruits are used for many medicinal purposes such as for balancing internal secretions and enhancing immunity. Besides this they are also used to treat urinary disorders, tinnitus, dizziness, constipation, sore throat, fever etc. The fruits of *M. alba* have a cooling and laxative property and are used in throat infection, dyspepsia and melancholia. Fruit juices check thirst, cools the blood, reduces high fever and works as a good appetizer. Fruits are also used for loss of appetite, flatulence and for controlling intestinal parasites like tapeworm.

Fig 8.2 Mulberry Jam

Mulberry fruits are reported as antidiabetic with antioxidative properties. Mulberry fruit strengthens the antioxidative defense system and reduces damaging oxidative substances in the erythrocytes of diabetes induced rats.

Mulberry Stem

Mulberry stem can also be used in medicines. The stems are antirheumatic, hypotensive, diuretic etc. The stem bark of mulberry is having purgative and vermifuge like properties. A tincture of the bark is used to relieve toothache. Mulberry leftover waste and dried stems have good calorific value used as kitchen fuel in villages and briquets (coal) are made from it are used in hotels.

Mulberry Root

Mulberry roots are one of the important constituents of drug named, "*Glucosidase*" which is used in high blood pressure, besides the roots are used in medicines having cathartic and anthelmintic properties. Root juices of mulberries agglutinates the blood and is very useful in killing the worms in digestive tract.

Root bark of black mulberries (*Morus nigra*) contain calcium malate, tannins, fatty acids phytobaphenes, sugar, phytosterol, ceryl alcohol, and phosphoric acid. So, because of these every properties bark possess purgative and vermifuge like properties, besides it reduces the blood sugar level in diabetic patients.

8.4 Contents of Mulberry leaf

Mulberry leaf contains crude protein Morin about 25%~45%, carbohydrate 20%~25%, crude fat 5%, rich in calcium, potassium, Vitamin C, Vitamin B1, Vitamin B2, Vitamin A, etc. Cu, Zinc, boron, magnesium etc.,

Mulberry leaf contains Rutin, Quercetin, Isoquercitrin, Morace-tin (Quercetin-3-Triglucoside), beta- Sitosterol, Campestero1H, beta-Sitosterol, beta-D- glucooside, lupeol, Myoinosito, 10.18%, lnokosterone, Bedysterone, Hemolysin, Chlorogenic acid, oxalic acid, Fumaric acid, tartaric acid, citricacid, Palmiticacid, 1-hentriacontanol, Hydroxyeoumarin, sugar, glucoside, Glucose, Aspartic acid and GIutaminic acid. Vitamin C 200~300 microgram, Gluta-thione l40~400 microgram, polieacid,105 microgram, Folinic acid 22 microgram, Vitamin B_1 460 micrograms, Vitamin B_2 300~800 micrograms, choline, trigonelline.

8.4 Summary

1. The Mulberry leaf is the exclusive food of the silk worm *Bombyx mori(L).* T
2. The growth of the silk worm very much depends on the quality of leaves fed to them.
3. The leaf quality is influenced by various factors such as soil, pruning, fertilizer, rain fall, irrigation, etc.,
4. Mulberry grown on loamy soil contain more water, protein and less carbohydrate and fibre, Further the leaves mature slowly
5. We can proudly say that "Nothing is waste in Sericulture".
6. It gives lot of scope for self-employment where many persons are involved in processing, collecting and transporting of bye-products
7. The fruits are edible and rich in C Vitamin, can also be used in the manufacture of Jam and in Europe mulberry is exclusively grown for its fruits from which wine is made.
8. The stem in the trees is white in colour, soft and flexible. It is in great demand in the manufacture of sports goods.
9. Many agricultural implements can also be fashioned out of the stem. The wood pulp of the stem is a good raw material for the manufacture of quality paper.
10. Mulberry leaves constitute a good cattle feed. It is known that this feed increases the milk yield.
11. Various parts of the plant body have a high medicinal value and are used in the Ayurvedic system of medicine.
12. The medicinal properties of mulberry leaf are recognized for its diuretic, blood sugar and blood pressure reducing effects.
13. The mulberry fruits are used for many medicinal purposes such as for balancing internal secretions and enhancing immunity.

14. Fruits are also used to treat urinary disorders, tinnitus, dizziness, constipation, sore throat, fever etc.
15. The stems are antirheumatic, hypotensive, diuretic etc. The stem bark of mulberry is having purgative and vermifuge like properties.
16. Mulberry roots are one of the important constituents of drug named, "*Glucosidase*" which is used in high blood pressure.
17. Root juices of mulberries agglutinates the blood and is very useful in killing the worms in digestive tract

8.5 Short answer questions

1. What is the leftover percentage Nitrogen, Potassium and Phosphorous in mulberry leaf.
2. Mention contents mulberry fruit.
3. Mention contents mulberry leaf.
4. Mention contents mulberry bark and root
5. Mention uses of mulberry fruit.
6. Mention few important medicinal uses of bark and roots of Mulberry.
7. Mention few important commercial uses of mulberry leaves and fruits.
8. What are the Vitamins present in mulberry leaf and fruit.

8.5 Essay questions

1. Write a detail notes on different bye-products of mulberry.
2. Discuss briefly self-employment opportunities in mulberry bye-product industry.
3. Write a brief note on medicinal uses of mulberry.

GLOSSARY

Acid soils	-	Soils with pH lower than 7.0
Agro climatology	-	Deals with relationship of climatic regions and agricultural production.
Air layering or gooting	-	A propagation to induce roots on an aerial shoot.
Alluvial soil	-	These are formed by the deposition of silt by rivers.
Androecium	-	Collective name for the stamens of a flower.
Atmosphere	-	It is a colourless, tasteless and odourless mixture of gasses that surround the earth.
Bio-fertilizers	-	The microorganisms which are capable of fixing nitrogen.
Bivoltine	-	Silkworm which completes its life cycle twice in an year (one generation/year).
Black soil	-	Soil derived from the Deccan trap is black cotton soil, characterized by black colour.
Bud	-	Compact, undeveloped shoot, consisting of a short stem bearing crowded, overlapping, immature leaves.
Callus	-	Superficial tissue-developing in woody plants in response to wounding, usually by activity of cambium, protecting the injured surface.
Catkin	-	Kind of inflorescence
Climatology	-	Deals with the factors which determine and control the distribution of climate over the earth's surface.
Cloud	-	It is an aggregate of minute drops of water suspended in the air at higher altitudes.

Cocoon	-	The silken shell spun by the silkworm larvae that serves as a protective covering to the insect during its pupal stage of existence.
Complex fertilizer	-	The fertilizer which contains two or more nutrients.
Compost	-	A mass of rotted organic matter made from waste in a pit with a view to bring the plant nutrients into a more readily available form.
Condensation	-	Change of water vapour (gaseous state) into liquid state at a very cold temperature.
Cut form	-	The method, by which the shape and form of mulberry plant is maintained is called a cut form.
Cutting	-	A mulberry plant shoots of pencil thick, 6-8 months old with 3-4 buds and used for asexual propagation.
Cystolith	-	Stalked body consisting of in growth of cell wall bearing deposit of calcium carbonate, found in epidermal cells of certain plants.
Dew	-	Condensation of atmospheric water vapour at low temperature (night).
DFLs	-	Disease Free Layings (silkworm eggs) Male and female flowers.
Dioecious	-	Plants with separate male and female flowers are present on different plants.
Dormancy	-	A resting condition, alive, but with relatively inactive metabolism. It involves cessation of growth.
Drainage	-	Removal of surplus or excess water from soil.
Drizzle	-	Fine droplets less than O.5mm dia.
Earthworm	-	A soil inhabiting cylindrical worm with rings on its body.

Apogeic	-	Earthworms which cannot form burrows in the soil and live in organic matter above the ground.
Farm waste	-	Means useless, unused, unwanted or discarded materials produced by farm animals.
Farmyard manure	-	Refers to the decomposed mixture of dung and urine of farm animals along with the litter and leftover material from roughages or fodder fed to cattle.
Fertile soil	-	The soil which supplies enough of necessary plant food elements.
Fertilization	-	Union of two haploid nuclei of sexual reproduction.
Fertilizers	-	These are inorganic materials of concentrated nature.
Flower	-	Specialized reproductive shoot, consisting of an axis on which are inserted four different sorts of organs i.e., sepals, petals, androeium, gynoecium.
Fog	-	Joining of water vapour with air nearer to soil surface.
Frost	-	Formation of ice pieces on cool surfaces.
Germination	-	The emergence and development from the seed embryo of those essential structures, which for the kind of seed in question indicate its ability to produce a normal plant under favorable conditions.
Glaze	-	Rain falling on surface having subfreezing temperature, freezes into a sheet.
Grafting	-	Joining a branch of one plant into a rooted plant, and they unite with an organic union and finally grow as one plant.
Gynoecium	-	Collective name for the carpals of a flower.

Hail	-	Similar to sleet but larger in size.
Harvesting	-	It is cutting the crop from the field for its utilization. It is important to harvest a crop at the time that will allow the maximum yield and at the same. time ensure a product of high quality.
Haze	-	Joining of dust particles with water vapour resulting in a cloud like form.
Herbarium	-	It is a perennial collection of most representative specimen of plants.
Hoeing	-	Stirring the soil with hoes and is mainly practiced after the sowing is done.
Humidity	-	It refers to the water vapour content of the atmosphere.
Humus	-	Organic matter that is mixed in the soil which looses its natural shape, structure and become part of soil.
Humus	-	A dark material in the soil derived from dead organic matter.
Idioblasts	-	Cell distinctly different in form, structure or contents from others in same tissue.
Igneou Rock	-	It is formed cooling, hardening and crystallizing of various kinds of lava and differs widely in their chemical composition.
Kolar system of Pruning	-	Is the method of pruning the whole shoot close to ground level after each harvest?
Land preparation	-	It is digging or ploughing, disking, harrowing, planking and leveling to bring the soil into a fine tilt. It also includes preparation of beds for transplanting.

Laterite soils	-	Soils derived from the atmosphere weathering of several types of rocks.
Layering	-	A process of development of roots on a stem while it is still attached to the parent plant.
Layout	-	Means the division or arrangement of the farm land into fields and the location and arrangement of irrigation structure, irrigation channels, farm buildings, farm needs, farm fencing, farm drains etc.
Major nutrients	-	The nutrients which are required in large quantities.
Metamorphic rock	-	It results from either igneous or sedimentary by the action of heat and pressure to bring out considerable change in texture and mineral composition.
Meteorology	-	Deals with laws and principles applied to atmospheric phenomenon.
Micro nutrients	-	The nutrients which are required in small quantities.
Microbes	-	Unicellular organisms without distinct nucleus.
Micropyle	-	Canal formed by extension of integument of ovule beyond apex of nucleus, recognizable in mature seed as a minute pore in seed coat through which water enters when seed begins to germinate.
Mist	-	The state of water droplets completely evaporate before reaching the ground.
Monoecious	-	Male and female flowers are found on same plants.
Mulberry	-	Hardy perennial tree. Silkworm (B.mori) feed on its leaves.
Mulch	-	Application of any material on the soil surface to check evaporation and improve soil water.

Multi voltine	-	Silkworm which completes its life cycle more than two in an year (one generation/year).
Night soil	-	Solid and liquid excreta of human beings.
Nursery	-	A process of plant propagation in which seedlings or cuttings are raised in a small area w1der intensive care.
Nutrient Medium	-	A medium having sugar, inorganic substances, vitamins which are necessary for plant growth.
Palatable	-	Desire of eating
Peaty and organic soils	-	Formed as a result of accumulation large amounts of organic matter in the soil due to submerge in water during the monsoon.
Perennial	-	Plant that continues its growth from year to year.
Petal	-	One of parts forming corolla of a flower, usually brightly coloured and conspicuous.
Petiole	-	Leaf stalk
pH	-	A quantitative expression for acidity or alkalinity of a solution i.e., concentration of hydrogen or hydroxyl Ions.
Phyllotaxy	-	Arrangement of leaves on stem, whorled, opposite, alternate or spiral.
Pollination	-	Transference of pollen from anther to stigma.
Precipitation	-	The water vapour condenses into different size and reach earth surface.
Pruning	-	Methodical removal of certain branches of plant so as to give the plant (i) convenient shape and size (ii) to increase leaf yield (iii) improve leaf quality.
Rainfall	-	It is precipitation in the form of liquid drops larger than

		0.5mm dia.
Reclamation	-	Rectifying the soil chemical properties by adding required materials. It is carried on by gypsum, green manures, Sulphur and leaching.
Red soil	-	These are formed from granites, shales, quartzite stones. Red colour is due to iron oxides formed in the soil.
Rime	-	It is a state of freezing fog.
Root	-	The part of vascular part that usually grows down wards into the soil, anchoring plant and absorbing water and nutrient salts.
Saline and alkaline soils	-	Soils formed as a result of accumulation of soluble salts in the root zone. Salts mainly contain chlorines, sulphates of sodium, calcium and magnesium.
Sapling	-	A plant grown by vegetative propagation.
Scion	-	The part of the graft which is to become shoot of the new plant.
Scroop	-	A property of finished silk such that the material has a characteristic feel and gives a cracking or a crunching noise when crushed by hand. It is produced by treating the silk in acid drying without washing.
Sedentary Rock	-	It is formed from igneous rocks by consolidation of fragmentary rock material and decomposition products.
Seed	-	Product of a fertilized ovule consisting of an embryo enclosed by protective seed coat derived from the integument.
Seed	-	It is a fertilized mature ovule with a small plant (embryo) enclosed within the fruit (ovary)

Seed bed	-	The place where the seeds germinate, and are the medium from which the resulting plants, through their roots, obtain moisture and mineral nutrients.
Seedling	-	A plant grown from a seed.
Sepal	-	One of the parts forming calyx of dicotyledonous flower, usually green and leaf like.
Sericulture	-	An art and science of raising silk worms in production of cocoons.
Sewage	-	Human excreta flushed out with water
Silk	-	A protein substance which is secreted in the fluid state by silkworm (caterpillar stage of several silk moths) and which on exposure to air hardens in the form of thread. It is mainly composed of sericin and pebrine and other substances.
Sleet	-	Solid precipitation of small particles of clear ice.
Snow	-	It is formed by sublimation of water vapour at subfreezing temperature resulting solid ice flakes.
Soil	-	A thin layer of earth's crust which serves as a natural medium for the plant growth.
Soil erosion	-	The process of detachment of soil particles from the parent body and transportation by wind or water.
Soil fertility	-	The ability of soil to provide all the essential plant nutrients in available form and in a suitable balance.
Soil moisture	-	The water found in spaces between soil particles and as a film on the surface of these colloidal aggregations.
Soil profile	-	Vertical section of the soil through all the horizons, extending up to the parent material.

Soil structure	-	It refers to the arrangement of soil particles both primary and secondary which influence aeration, permeability, water holding capacity factors.
Soil testing	-	The process of chemical examination of a soil sample for its physiochemical properties like pH, electrical conductivity, $CaCO_3$, organic carbon and available nitrogen, phosphorus and potassium.
Soil texture	-	Indicates the relative percentage of coarse and fine soil particles.
Soil texture		Refers to the relative percentage of sand silt and clay in a soil.
Sowing	-	Means placing the seed in the soil.
Spacing	-	A process in cultivation where proper spacing between the rows and between plants enables equal distribution of soil nutrients.
Stipule	-	Small, usually leaf-like appendage, found one on either side of leaf stalk in many plants, protecting axillary bud and often taking part in photosynthesis.
Stock	-	The part of the graft which is to become root of the new plant
Straight fertilizer	-	The fertilizer which contains only one plant nutrient.
Succulent	-	Plant with sufficient amount of water having a fresh appearance.
Tissue & Organ Culture	-	A process to grow cells, tissues, organs in an artificial medium.
Topography	-	Ups and down in the soil (land) indicating the levels of the sol.
Training	-	Systematic pruning to give a. specific shape to a mulberry

tree is called training.

Transplantation - Uprooting of saplings or seedlings from nursery and planting in the field.

Uni voltine - Silkworm which completes its life cycle once in an year (one generation/year).

Vermi compost - It is a physically, chemically and biologically degraded organic material produced by earthworms which consists mainly of digested soil and organic matter. It is rich in nitrogen, phosphorus, magnesiun1, zinc and calcium in simple forms, thus plant root system can readily absorb them.

Vermi culture - Cultivation of a biological material (earth worm) or its propagation on or in a substrate under semi-natural condition.

Viable - Able to live. Of seeds or spores, able to germinate.

Weather - It is a state of atmosphere at a given place and at a given time.

Weed - Plant growing out of place.

Weed Control - The process reducing weeds growth or weed infestation to an acceptable level.

Weed extraction - Complete elimination of all unwanted plants fron1 the area of main crop.

Wind break - Any structure that obstructs wind velocity to reduce it.

SERICULTURE

Paper - II

SILKWORM REARING REQUIREMENTS &

MANAGEMENTS

INDEX

UNIT 1

Vanya Silkworms

Structure

Learning Objectives

With this unit the student will be able to understand

- Importance of non-mulberry silk worms.
- Distribution of non- mulberry silkworms.
- The life cycle and salient features of non- mulberry silkworms.

1.1 Introduction

There are four major types of silkworms of commercial importance, which fed on number of food plants. India is unique in its biodiversity and bounty of nature in having all four varieties of silks. The other varieties of silks are generally termed as non-mulberry silks, namely: Eri, Muga, Tasar etc., where these silkworms live on nature grown host plants. These groups have been now given a new identity and are collectively known as “Vanya silks”.

From last decade, Vanya silks have assumed more importance in view of the scope for the transformation of this age- old tradition of wild culturing in to semi domesticated culture and its commercial. production gained its own importance in silk industry

The major challenge is to utilize the natural resources to bring about a balanced development of Vanya silks without much disturbance to the forest ecology, traditional culture and the way of life of the primary producers. When Vanya silkworms are reared on the food plants, they feed on the leaves and produce not only cocoons but also the litters excreted in and around the plants results in effective nutrient recycling.

1.2 Distribution

Tasar: China and India are major producers of Tasar. In India Jharkhand, Chhattisgarh contributing 70% of the production, Andhra Pradesh, Orissa, West Bengal in appreciable quantities, while U.P, Maharashtra, Bihar and Madhya Pradesh are minor producing states.

In Andhra Pradesh Tasar growing districts are Nellore and East Godavari, while in Telangana Adilabad, Karim Nagar, Warangal, Khammam .

Muga: Assam is traditional producer, 95% of Tasar produced in India is from Assam. To a small extent it is seen in Meghalaya.

Eri: Assam, Nagaland, Meghalaya and Manipur contribute to 98% of countries production and in small scale in Arunachal Pradesh,Telangana, Uttar Pradesh, Bihar, Orissa, West Bengal, Andhra Pradesh and Tamilnadu.

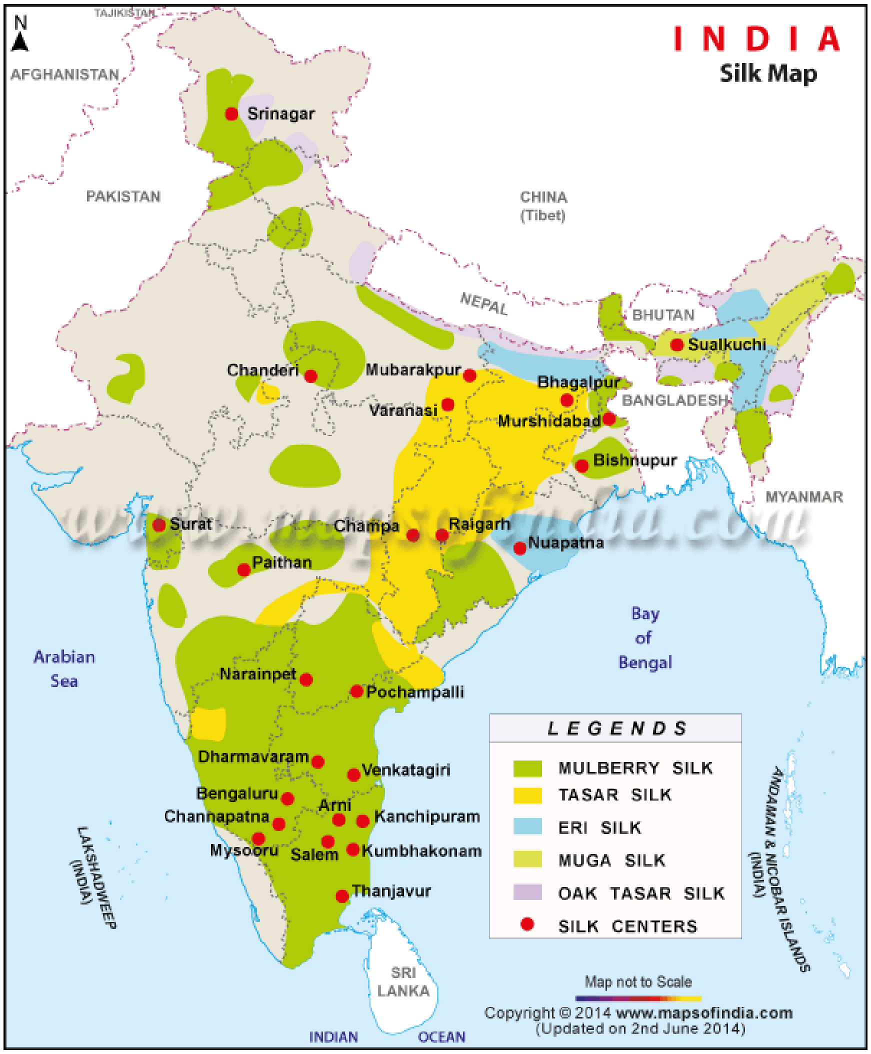


Fig. 1.1 Distribution Vanya sericulture in India

1.3. Salient features of Non-mulberry silkworms

Tasar: The word tasar, apparently derives from the Sanskrit word. Trasara {shuttle} and mentioned in literature of 1590 BC.

- Tasar silkworm, *Antheraea mylitta* is a natural fauna of tropical India.
- Wide distribution and polyphagous nature of this insect species had resulted in extensive variation in the population.
- About 19 races have been reported in this species which mainly feed on *Terminalia species* and *Shorea robusta* and several secondary food plants.
- The Eco races are Uni, Bi or Trivoltine depending upon the geo-ecological conditions and differ from each other in qualitative and quantitative traits.
- Tasar cocoons are reported to be largest among the silk producing in the world.
- Tasar silk filament has its own distinctive color, is coarse to feel but has higher tensile strength and elongation than mulberry silk filament.
- These properties have made tasar silk a competent and desirable as mulberry silk.

Muga: Muga silkworm is unique among silk producing *Saturnidae* moths. Native of Assam and named after Assamese word “muga” which indicates the amber (brown) color of cocoon.

- It belongs to same family as Tasar.
- It is popular for its natural golden color, glossy fine textures and durability.
- *Antheria assama* is an endemic species prevalent in the Brahmaputra valley and adjoining hills.
- It is a polyphagous insect, which feeds on leaves of Som, Soalu and other plants.
- *A. assama* is confined to only Assam state of India. Empirical observations show that the population is declining due to depletion in genetic variability.
- Their unique properties of providing golden luster to the silk thread. The popular items made from this silk are ‘dhothi’,’chaddar’,’chapkan,’pugree’and mekhala.

Eri : The name eri derives from the Assamese word 'era', which means castor-oil plant, the main food plant of this silkworm.

- Scientifically called *Samia cynthia ricini* a multivoltine silkworm commonly called as 'eri silkworm' is known for its white or brick-red eri silk.

- The primary food plant of this polyphagous insect is castor (*Ricinus communis L.*), but it also feeds on a wide range of food plants such as *Heteropanax fragrans, Manihot utilissima, Evodia flaxinifolia, Ailenthus gradulosa* etc.

- The wild *S. C. ricini* silkworm completes one to three generations per year depending on geographical position and climatic conditions of the region, however, up to six generations occur in the domesticated cultures.

- Populations of *S.C.ricini*, that have been commercially exploited and are present in different regions of north-east India show wide morphological and quantitative variations.
- Eri silkworms were successfully acclimatized in America and Europe but could not take firm hold.

1.3.1 B. Life cycle of Tasar

Scientific name**:** ***Antherae mylitta.***

Primary food plants: ***Terminalia tomentosa*****,** ***Terminalia arjuna***.

Secondary food plants: ***Terminalia catappa, Zizyphus jujube.***

Egg: The egg is oval in shape, dorsoventrally symmetrical along the anterio posterior axis, about 3mm in length and 2.5 mm in diameter. It weighs approximately 10 mg at ovi-position and it is dark brown in color. Eggs undergo incubation for 3-5 days.

Larva: The larva is elongate, cylindrical and hairy, they have typical cruciform or tapering on both sides shape. Head is bent and more clearly visible from lower side (hypognathous). The larval body is soft in early stages which becomes tough and leathery as it grows. On hatching it is dull brownish yellow with black head. The body normally turns green and the head brown after 48 hours, but also yellow, blue and almond colored larvae are seen occasionally. The size 13 × 2.1 cm and weight at maturity is about and 50gms.The larva passes 5 instars within a period of 26-28 days for I crop, 42-45 days II crop, 55-60 days III crop.

The prothoracic hood of the first instar larvae dorsally bears an oval black spot, which early in the second instar becomes M-shaped and then later become V-shaped with two dots. These marks are absent in the third instar but reappear in the fourth and fifth instar as two semi lunar red markings.

The anal flap bears a triangular black mark early in the first instar, which becomes V-shaped and brownish from the second instar onwards. The triangular mark on each of the claspers is black in the first two instars and brown in the succeeding instars.

Early first instar larvae have a black mid- dorsal line extending from the first to the seventh abdominal segment and a dumb-bell shaped black mark on the eighth segment. Laterally, the first seven abdominal segments have a pair of black vertical lines, and on the eighth abdominal segment there is a single oblique line. The vertical lines are replaced by V-shaped marks late in the first instar. Each of the abdominal feet bears a horizontal black mark. All these markings disappear in the later stages of development.

Third-instar larvae have a yellow lateral line extending from the second to the tenth abdominal segment. This line is bordered by a brown upper line in fourth and fifth-instar larvae.

Tubercles: The body of silkworm larvae has prominent protrusions or out growths on thoracic and abdominal segments called tubercles. They work as sensors for changes in environment related to temperature and humidity. Based on the position five types of tubercles are recognized as Dorsal (DT), upper lateral (LT), lower lateral (LLT) and caudal (CT). They are black in the first instar, orange red in the second and violet in the third to the fifth instar.

Hairs and Setae: The larval body is covered by hairs and setae. The hairs are white, minute and irregularly distributed over the body. The number and arrangement of setae vary according to the type of tubercle, body segment and age of the larvae, number of tubercular setae remains constant until the third instar and diminishes thereafter.

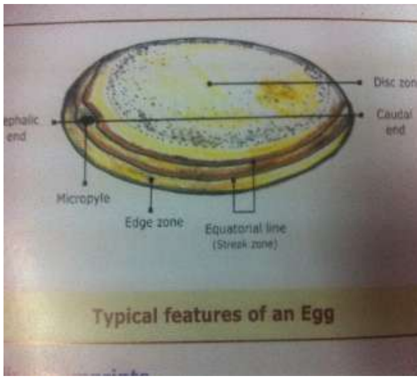
Shinning Spots: Silvery white lateral shinning spots, either oval or triangular, appear during the third instar at the foot of upper lateral tubercles of the second to the seventh abdominal segment. Six regular and thirty-eight irregular patterns have recorded. Plain larvae are also common. Other shinning spots are present at the base of the dorsal tubercles. These are brick red in green and yellow larvae and white in blue and almond-colored larvae.

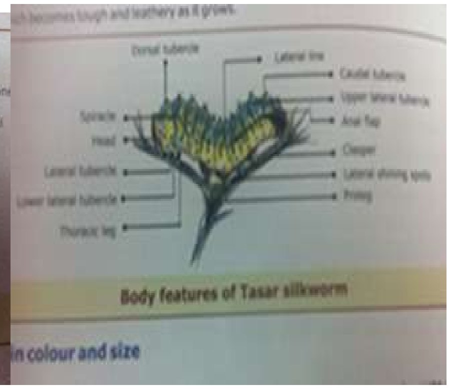
Sex markings: The sex markings appear late in the fifth instar as milky white spots on the ventral surface of the eighth and ninth abdominal segments.

Pupa: The pupa is oblique, having a well-defined and segmental body.
It is dark brown in color and weighs 10 to 12gms.

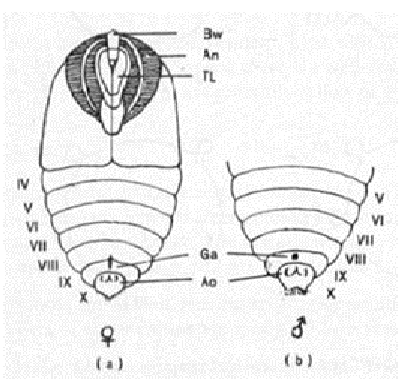
Cocoon: The cocoon is single shelled, pendent, oval, closed and reelable, having a hard, non-flossy shell with fine grains. At the anterior end, there is a well- formed dark brown peduncle with a ring at the distal end. The cocoons are generally yellow or grey. The females spin larger cocoons than the males.

Moth: The moths exhibit distinct sexual dimorphism. The females are bigger (4.5 cm), with a distended abdomen and narrow bi pectinate antennae (1.5 cm long). The males are smaller (4.0 cm), with a narrow abdomen and broad antennae. The females are polymorphic in color, being grey and yellow, whereas the males are brown. There are two pairs of wings attached to the middle and hind thoracic segments which differ in size. Each wing carries a vividly colored eye like patterned referred as ocellus. The colored core of the ocellus is called the hyaline area.





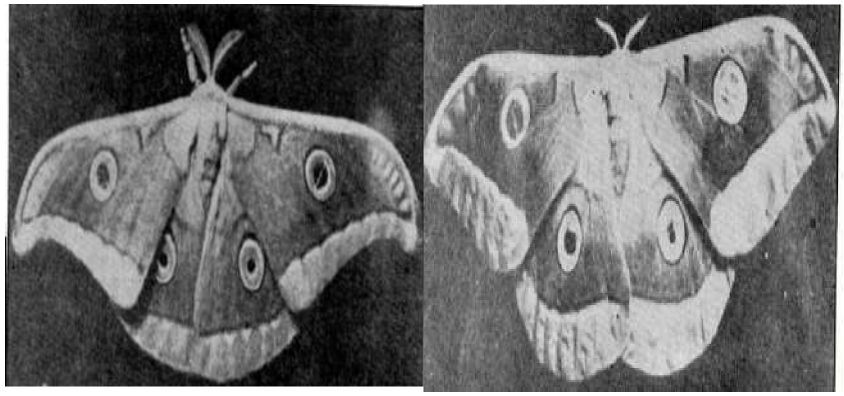
Egg B.Larva



Pupa **Cocoon**

Fig. 1.2. **Pupal Abdomen Segments**

Key : bw = brain window, An = antenna
TL= thoracic leg, Ga - genital apperture Ao = anal o



Male **Female**

Fig.1. 3 E) *A. mylitta* moth

Rearing

Tasar silkworm being wild semi domesticated, polyphagous, their rearing is outdoor which causes 50-55% loss due to mainly predators, diseases and pests. Tasar silk worms are mostly bivoltine or trivoltine. The cocoons are collected from the branches of food plants and marketed. The produce is measured in" Kahans" [1Kahan=1280cocoons] and sold in numerical lots, which are as follows.

Ganda[4cocoons], Pan [80cocoons] Kahan (1280 in Bihar,1600 In orissa,1000 in M.P), Khandi(4000 in Maharastra)

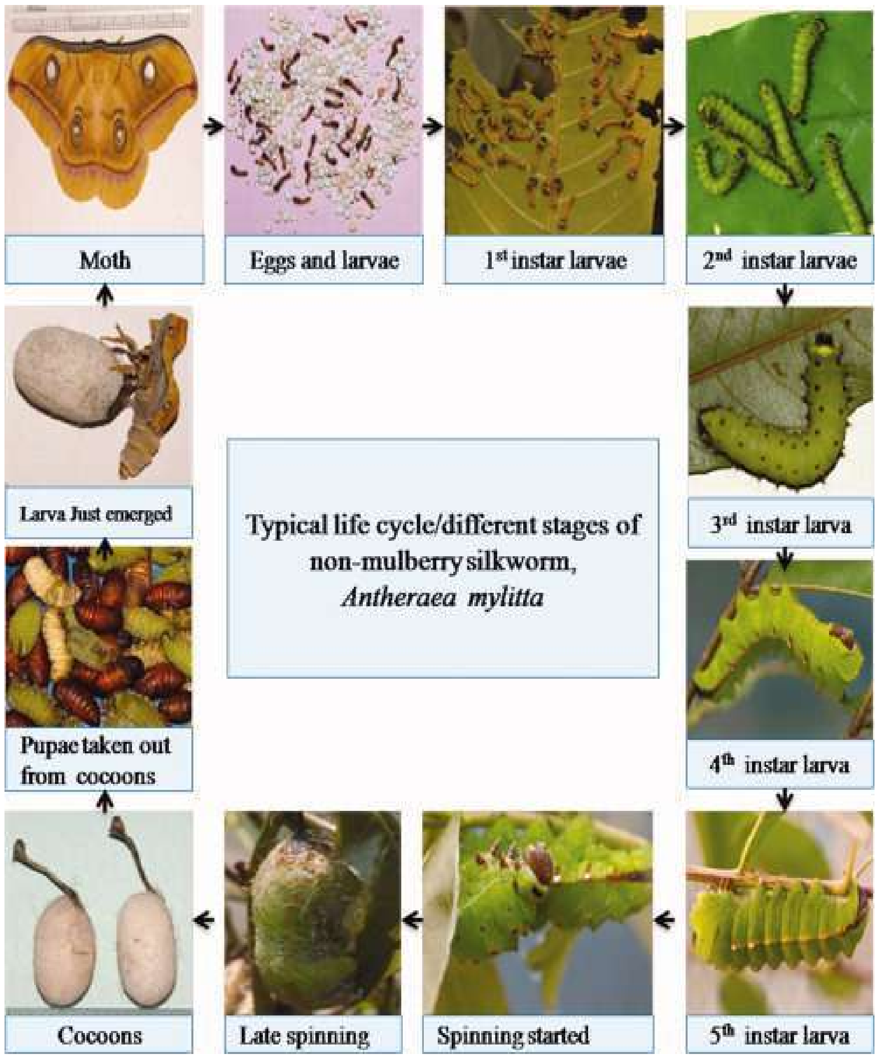


Fig. 1.4. Life cycle of Tasar

Life cycle of Muga

Scientific name: ***Antherea assamensis.***

Primary food plants: ***Machilus bombycina (som), Litsea polyantha (soalu).***

Secondary food plants: ***Litsea salicifolia, Celastrus monosperma.***

Egg: The eggs are streakless, brownish and weigh 9 mg. The incubation of eggs is 7 days in summer and 16 days in winter.

Larva: The larval period is 26-28 days in summer, 50-65 days in winter and undergoes four moults and passes through five instars. The newly hatched larva is characterized by prominent black inter segmental markings over the yellowish body with brown head. After the first moult the body turns green, while head remains brown on maturity attains 15gr weight. The prothoracic hood marking in the third instar, consists of two prominent rectangular black marks, later these are replaced by a pair of semi lunar deep brown markings.

Rectangular black mark is seen on posterior end of anal flap in the third instar and it becomes U-shaped in fourth instar with the two arms joining the lateral line, and in the fifth instar, it changes to V-shape with a black inner and a deep brown outer border.

The dorsal, upper lateral and lateral tubercles (DT, ULT and LT) are bluish and lower lateral tubercles are brown in the third instar. However, the first three change to brick red subsequently. The larval duration period in summer is 28-35 days whereas in winter 50-65 days.

Pupa: The pupa weighs about 5.7gms and copper brown in color.

Cocoon: The cocoon weighs about 6.3 gr, single shelled, light brown, oblong in shape, closed, slightly flossy, reelable and with a weak peduncle and with a soft shell about 0.5 gr. The cocoon is golden brown or glossy white in color.

Moth: The moths exhibit distinct sexual dimorphism. The female moths are larger than males. The fore and hind wings are brown, rarely with a pinkish tinge. The females have larger wings than the males and the ocellus of the female moth has a strikingly reduced hyaline area, which in fore wing is almost dot like and the hind wing a horizontal slit. The area of the ocellus is greater in the hind wings.

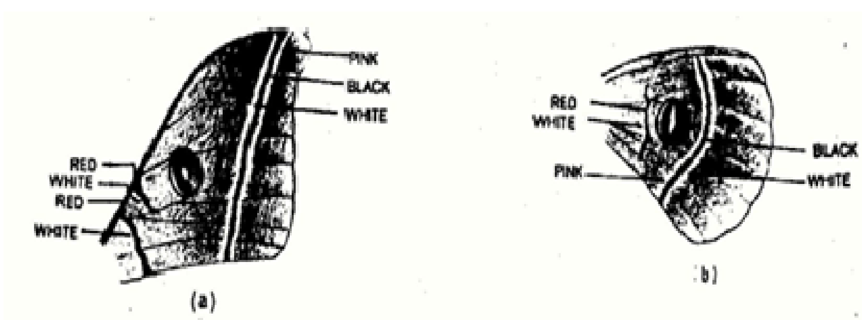


Fig. 1.5. Female Moths Wings

Rearing: Muga silkworm is a multi voltine species with 5-6 generation in a year reared in outdoors. Based on the Assamese calendar the different generations are termed as follows jarua, chotua, jethua , Aherua .Bhodia and Katia, out of all the autumn (katia) and spring (jethua) generations are more favorable for commercial rearing. The other seasons are generally useful for seed stock maintenance and multiplication.

Immediately after hatching larvae along with the moths in copulation position are tied on a straw bundle or tender twigs called khorika of the food plant. When the leaves are fully consumed by the larvae they are transferred to another tree by means of triangular bamboo trays called "chalooni". The ripen worms are placed on mountages for spinning. The mountage is called 'Jali" which is a bundle of dry twigs and leaves

A. Muga worms **B. Chaloni** **C. Cocoon Formation**

Fig. 1.6. Muga Rearing

Life cycle of Eri

Scientific name: *Cynthia ricini.*

Primary food plants: *Ricinus communis, Heteropanax fragrans.*

Secondary food plants: *Jatropa curas, Carica papaya, Plumera rubra.*

Eggs: The eggs are ovoid, candid white and weigh about 6 mgs.

Larva: The just hatched are greenish yellow and body color changes gradually to pure yellow by the end of third instar. The fully matured larva is translucent and covered with a white powdery substance and weighs 6 gr. Both spotted and unspotted larvae are seen, and spots are in single, double, zebra and semi-zebra type. The area around the antennae acquires a black dumb-bell shaped mark in the fourth instar, which in the fifth instar, splits into two oval dots.

The planta, anal flap and claspers are light yellow throughout the larval span. The planta has a horizontal blue band at the top. Early in the first instar, the markings on the anal flap and claspers are black and appear as a continuous band. In the second and third instars, the black marks are triangular on the anal flap and rectangular on the claspers. These marks disappear in the subsequent instars. The lateral line is creamy white and extends throughout the body length.

The tubercles are very conspicuous and tubular in shape. They are bluish at the base and cream at the tip. The setae are pointed and blackish, number 180 at third instar.

Pupa: The obtect adectious pupa does not depart from the basic saturnidae pattern. It weighs about 2.6gms.

Cocoon: It is elongated, soft, woolly, open mouthed, non-peduncle and non- reelable. It weighs about 3gms and exhibits color polymorphism, being brick red and creamy white. The cocoon shell weighs around 0.4gms.

Moth: The moths exhibit distinct sexual dimorphism. The females are larger than males. The wing span of male is lesser than female. The fore wings of both sexes are similar in structure and color pattern. The color is brownish, blackish or chocolate. The shape of ocellus is crescent shape. A conspicuous black spot, the pterostigma with a whitish tinge is present at the wing apex. In addition, the wing has a few white oblique lines.

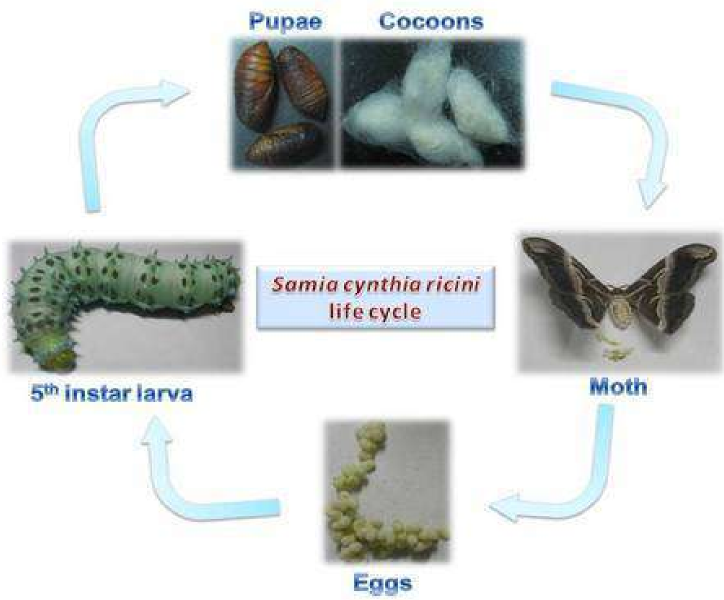


Fig. 1.7. Life Cycle of Eri

Rearing: Eri silkworm a multivoltine polyphagous in nature which is reared indoor**.** Rearing these silkworms is entirely different from other wild silkworms. It requires ideal rearing house and a rearing rack. Worms are mounted on split bamboo tape (chandrika pool). Rearing of 100- 125 layings from hatching to ripening requires about one metric ton of foliage.

The lifecycle of this silk moth runs for 49-53 days, depending upon climatic conditions. The duration shortens to around 49 days during the monsoon and the summer and lengths during the winter. Thus, six generations are possible in a year

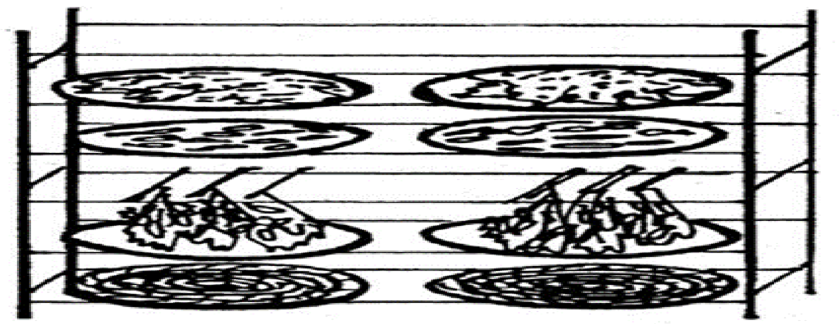


Fig. 1.8. Eri rearing

SUMMARY

- The silk obtained from other than mulberry silkworms are termed as non-mulberry silk.
- India is unique in producing all commercial varieties of silk i.e., mulberry, tasar, eri, muga.
- The wild silkworms which thrive on nature grown host plants are "Vanya silks."
- Sexual dimorphism - differentiation of two sexes by observing the external characters.
- Non-mulberry silks are practiced by the tribal people inhabiting mostly central, eastern and north-eastern regions.
- In recent years, tasar which used to be an item for domestic consumption has attracted the foreign markets, and exports.
- Muga silkworm is indigenous to the north- eastern region and found nowhere else in the world.
- Eri as an attracting modern silk fiber can be blended with other yarns imparting a special texture and feel to the fabric.

Short Answer Type Questions

1. Define Vanya silks or non-mulberry silks.
2. What is polyphagous?
3. Name the places which are producing tasar silk in India.
4. Which place is monopolized for muga silks?

5. Name the scientific names of Tasar, Eri and Muga silkworms.

6. Mention the food plants of all the non-mulberry silkworms.

7. What are the items made of Muga silk?

8. What is chalooni?

9 Write the characters of Tasar, Eri, and Muga cocoons

10 .What is ocellus

Long Answer Type Questions

1. Discuss the distribution of the non-mulberry silkworms

2. Describe the salient features of non-mulberry silkworms.

3. Explain the life cycle of Tasar silkworm.

4. Write about the life cycle of Muga silkworm.

5. Explain briefly the life cycle of Eri silkworm.

UNIT 2

Rearing house

Structure

Learning Objectives

- To understand the activities of the rearing house.
- To know about the facilities for rearing like , its site selection , orientation

2.1 Introduction

- To study about different model rearing houses in India.

Bombyx mori a lepidopteran insect which is highly domesticated but vulnerable to seasonal fluctuations and are reared in special rearing houses. Most of the commercial rearers in India are small farmers who previously were rearing silk worms in own home. Presently adapting to new technologies, the farmers have started to construct separate rearing houses for optimizing cocoon yield. With this environmental condition inside rearing houses are reduced to the minimum, where silkworms receive more uniform conditions. Late age rearings are taken up in specially constructed shoot rearing stands and also in the place of chandrica (bamboo mountage) plastic mountages are being used for mounting and hence no separate space is required for mounting.

The site for rearing house must be well elevated, ventilated and drained land should be selected. For the regions of high temperature and high humidity, rearing house should be built with good aeration and shade are available.

2.2 (A) Orientation of rearing house

The orientation of the building should be such that the interior is protected from direct sunlight. In tropical regions, the best orientation of the building will be north -south to avoid direct sunlight into the rooms.

Open verandah and shade trees have beneficial influence in moderating heat. When rooms face east or west, broad verandah should be provided, or shade trees should be planted on the exposed side. In temperate and sub-tropical region, rearing house should be constructed in north-south direction with doors and windows facing east-west. With this method, maximum sunlight is available to warmup the rearing rooms adequately.

2.2 Selection of building site

2.2 (B) Size of the rearing house

The size of the rearing house depends largely upon the no of DFLs to be reared and method of rearing. At present old traditional tray method of rearing is totally replaced by shoot rearing method. Space requirement is minimized in shelf or stand rearing and maximum in floor rearing. In general, a floor area 2sq. ft/dfl is required for tray method and 4sq. ft/dfl in the case of shoot feeding method.

2.2.1 Table showing space required for tray and shoot rearing

S.No	No of Dfls	Space required for tray rearing (sq. ft)	Space required for shoot rearing (sq. ft)
1	100	400	800
2	200	800	1600
3	400	1600	3200

(C). Points to remember in construction of rearing house

1. The width of room must lesser than to its length for better regulation of the temperature and humidity.
2. Windows should be provided with top and bottom ventilators for free circulation of air and its number would be according size of rearing house
3. Verandahs of 4ft-6ft should be provided around the shed for better shade, which also reduces radiation.
4. The roof should be high and built out of non-conducting material, the roof also covered with thatch, country tile etc depending on the need and the availability.
5. All windows, ventilators and doors are fixed with net to control entry of uzy fly.

6. It is a rat proof building provided with a projecting ledge of at least 0.35 to 0.40mt at plinth level effectivelyprevent the rats entry.
7. The stairs should also be movable so that the same could be pushed away
8. during night time and the building rendered completely rat and other predator proof

2.3 C.S.B. Model rearing house

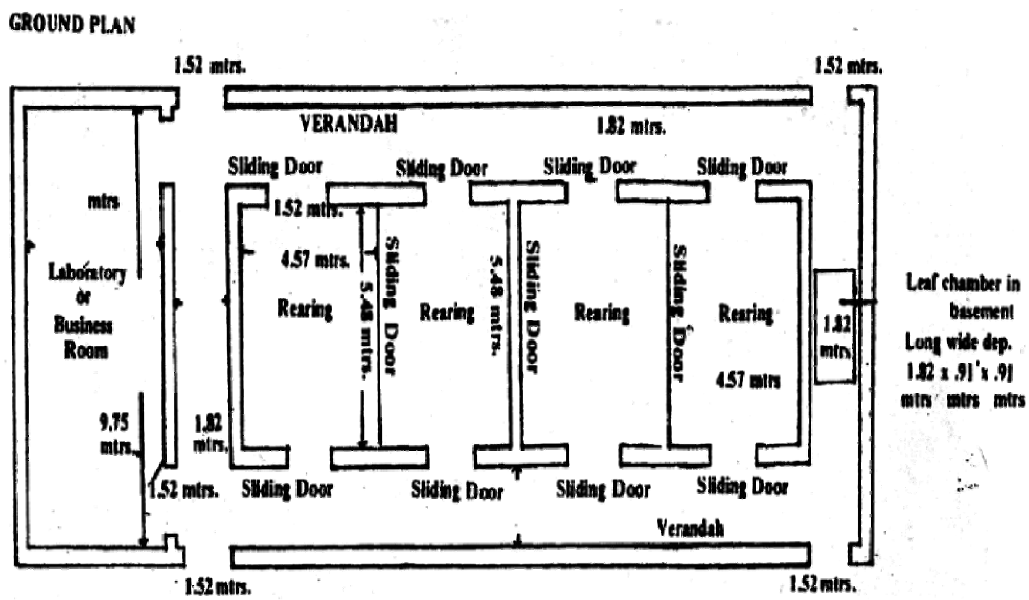


Fig 2.1 CSB Model rearing house for tray rearing

Chawki Rearing House

In view of producing chawki worms on commercial basis a separate rearing house is required with adequate space and sufficient ventilation. The rearing building should be constructed away from dwelling houses and late age rearing houses and preferably close to the chawki mulberry garden. The ideal CRC building is designed by CSR&TI , Mysore for rearing 5000 DFLs/crop and 32 crops in a year. The CRC bulding should have RCC roof and adequate facilities for good ventilation. If the CRC building is larger than required, maintenance of micro-climate would become tougher. Hence it is advisable to select a smaller rearing room with proper windows and doors to close for maintaining the temperature and humidity.

The CRC room can also be used as incubation room for silkworm eggs. The CRC building should possess a rearing hall measuring 32 X 30 ft and two rooms of 10 X 20 ft each for leaf preservation and for sorting rearing

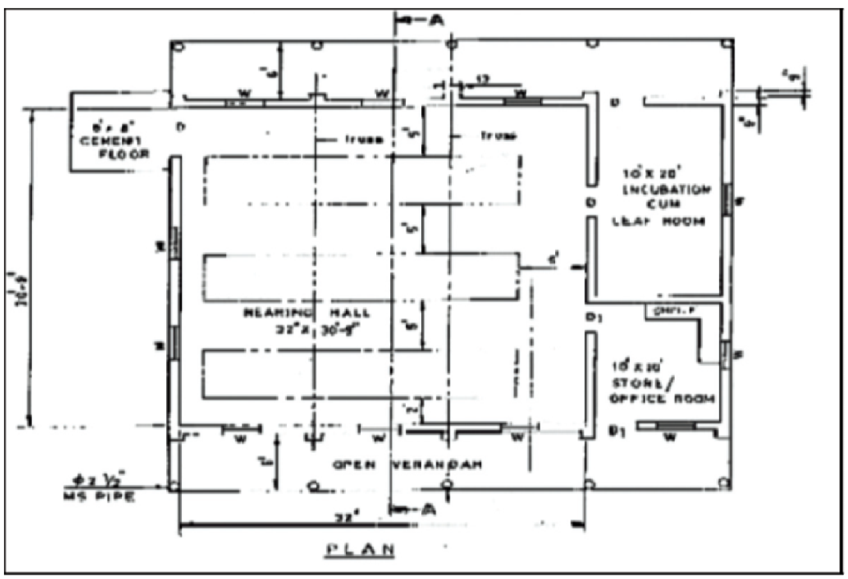


Fig 2.2.A Ground plan for chawki rearing house 5000 Dfls /crop

Fig 2.3 B. Chawki rearing house

2.4 Types of rearing houses

i. Mud wall and mangalore tiled roof.

ii. Mud wall and country tiled roof.

iii. Mud wall and thatched roof.

iv. Plank wall and thatched roof.

v. Raised platform type floor, bamboo mat wall and thatched roof.

vi. Double brick wall and Mangalore tiled roof.

vii. R. c. c building

Number of tiers	Length of rearing house in feet
For 4 tier shoot rearing stand	0.20 x no. of dfls + 10
For 5 tier shoot rearing stand	0.16 x no. of dfls + 10

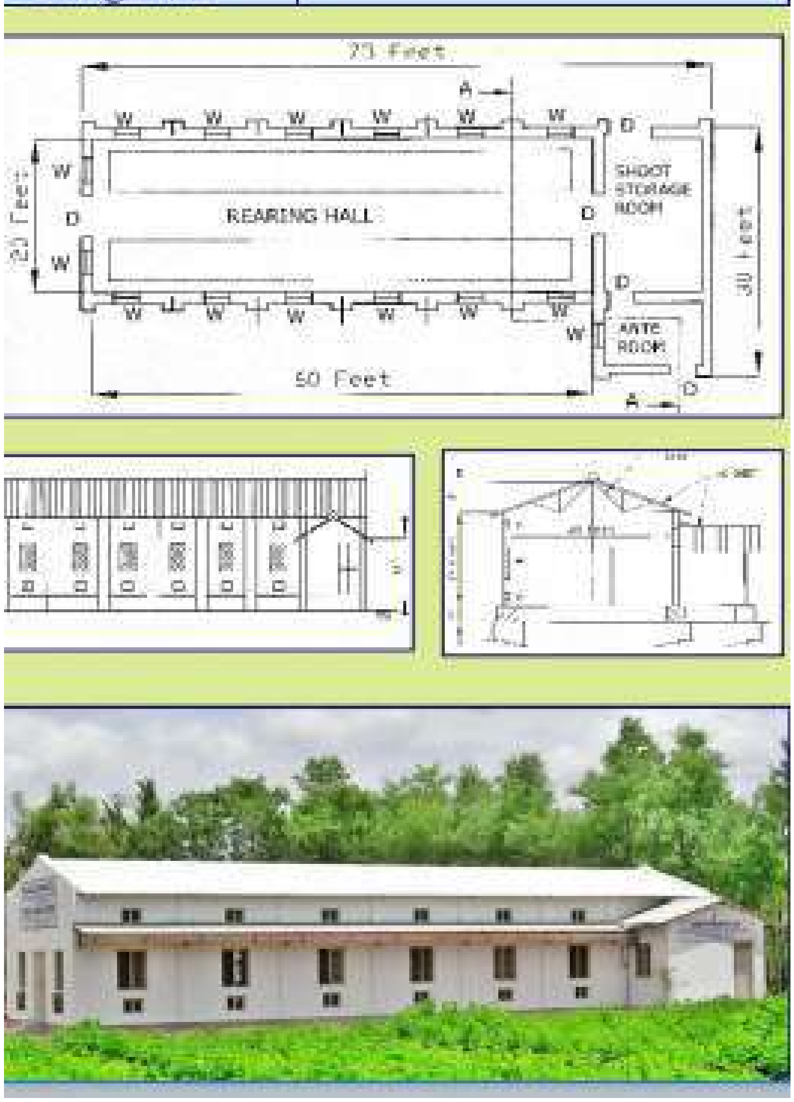


Fig 2.4 CSB Model rearing house for shoot rearing

Fig.2.5 Different model rearing houses

Summary

- Silkworm rearing needs specified environmental conditions. Hence, rearing houses are planned to provide the conditions required, for better results.
- Rearing site supply a plenty full of fresh pure air, without being exposed to violent draughts or direct heat of sun.
- The best orientation of rearing house is north and south following northwest and southeast, lastly east.
- Commercial farmers must maintain a separate rearing house for young age and late age to regulate the necessary environmental conditions.
- Rearing houses constructed with mud walls and thatched roof are good for tropical

Short Answer Type Questions

conditions.

1. Which is the best orientation for rearing house?
2. Mention different types of rearing houses.
3. Which type of rearing house is ideal for tropical conditions?
4. How uzi entry is restricted in designing of rearing house?

Long Answer Type Questions

5. How the chawki rearing room should be designed?

1. Selection of rearing site is important-justify it.
2. Discuss the orientation of rearing house.
3. Describe and draw ground plan of the CSB model rearing house.
4. Describe and draw ground plan of Chawki rearing house.
5. Mention few points to remember in construction of rearing house.

PAPER II SILKWORM REARING REQUIREMENTS & MANAGEMENT

UNIT 3

Rearing Equipment

Structure

Learning Objectives

- To understand about the rearing equipment required
- To know about the disinfectants used in rearing house

3.1 Introduction

In small scale silkworm rearing equipment used are of low cost, which were made of locally available materials to reduce the cost of establishment. For large scale rearings the equipment must be of standard material with mechanization to reduce cost of labor.

In silkworm rearing house the equipment's should be properly arranged without wasting the space and it should be clean and convenient for practicing disinfection. The old traditional method of tray rearing is now replaced by shoot rearing method, where within a limited space the worms are reared and process of rearing is simplified with reduced cost of production. The size of the silkworm rearing and number of equipment required depends on the extent of mulberry area.

3.2 Equipment and uses

(a) Rearing stands

The stands made of iron, wood or bamboo are used for chawki rearing and shoots are used for late age rearing. Stands of 2.5m height, 1.5m length and a width of 0.65m with10-12 shelves with a space of 0.15m to accommodate ten rearing trays, six stands are required for each rearing room. Fig. 3.1.

(b) Rearing trays:

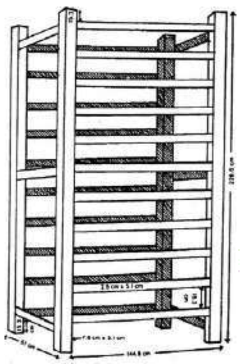
Rearing trays made with wooden frames and plywood bottom with dimensions of 0.9 cm x 1.2 cm are used for chawki rearing and four such trays are required to rear 100 Dfls upto second instar and 8 to 10 trays are required up to 3rd instar. Box type arrangement of trays also practiced for chawki rearing,

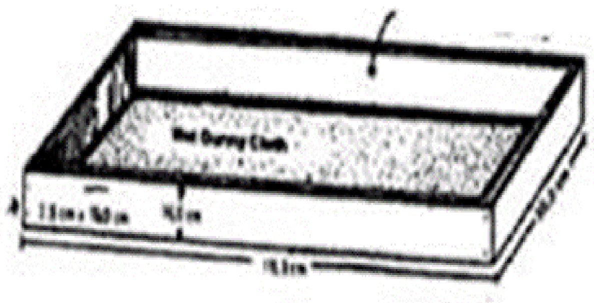
(c) Shoot rearingstand:

Shoot rearing stand having 4 tiers of 5to 5 ft width is convenient, the length of the stand is optional based on building size. The first rack should be at least 1ft above the floor. There should be a gap of 2ft between rack to rack. A moving space of 2ft gap between stands; and at least 4-6 ft working space has to be maintained. A gap of 3-4ft between the roof of the building and upper most rack is a must. (Fig. 3.10)

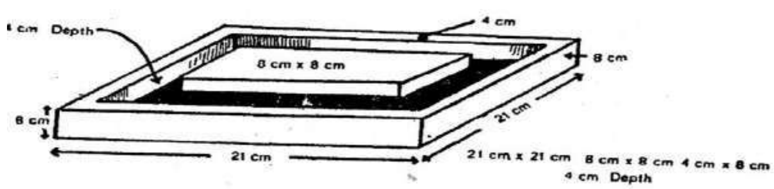
(d) Ant wells

Ants are serious menace to silkworms, hence ant wells are used to avoid there crawling on to the stands. The legs of chawki rearing stands are rested on the ant well and are filled with water. Enamel or aluminum trays of convenient size are sufficient for this purpose. Cement ant wells of 21x21x8cmsize with a groove of 4cm can also be used. Fig. 3.1.





(a) **Rearing Stand** **(b) Rearing tray**



Ant well

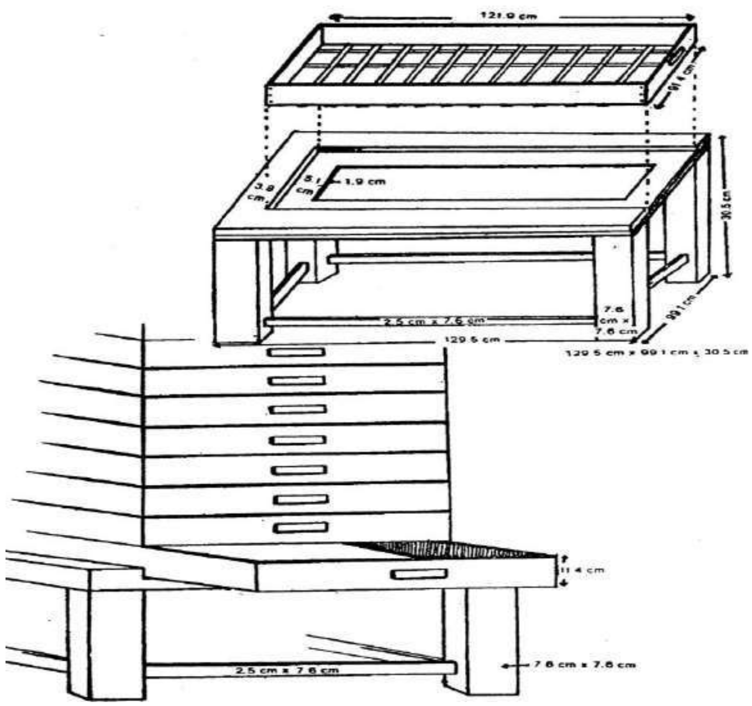


Fig. 3.1 Rearing Equipment

Box rearing

(e) Paraffin Paper

This is a thick craft paper coated with paraffin wax is used to prevent evaporation of moisture and to maintain high humidity in the rearing bed of the young silkworms there by preventing drying of chopped leaves.

(f) Foam rubber strips

Long foam strips of 2.5cm wide and 2.5cm thick, soaked in water are placed all around the bed of young worms. Thick folding of newspaper soaked in water may be used instead of foam strips. This is used to maintain high humidity in bed of young worms.

(g) Chopsticks

The bamboo stick is 17.5 to 22cm long, thin girth and tapering. At the thick end the two sticks are connected by a small thread. These sticks are used like forceps for picking up the worms for hygienic reasons and to prevent damage of young worms. (Fig. 3.3)

(h) Feather

Birds feather, preferably white ones are used for brushing newly hatched larvae from the egg card to the rearing trays and to spread the young worms during spacing operations. (Fig. 3.3)

(i) Chopping board

This is a rectangular board made of soft wood used for cutting mulberry leaf in the desired size for feeding the worms in different instars. The chopping board size of 0’9x0’9m and 5cm thick or any other convenient size.

(j) Chopping knives

Chopping knives are used for cutting the mulberry leaves. They are usually 0.3-0.5m long with a broad knife blade and wooden handle. (Fig. 3.3)

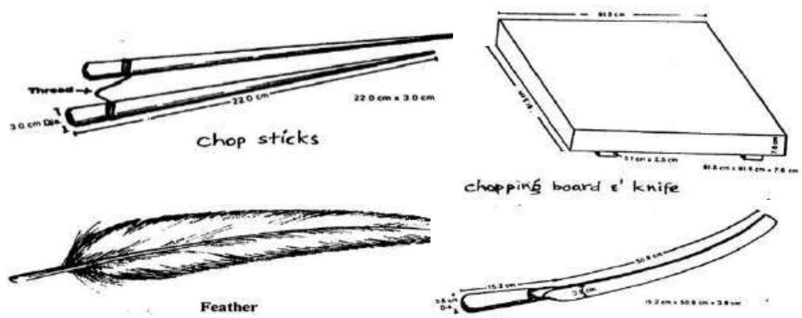


Fig. 3.2. Rearing Equipment

(a) Mats

These are placed below the chopping board prior to chopping and used to collect cut leaves. Clean newspaper may be used instead. They prevent the dust and dirt on the floor getting mixed with the leaves.

(b) Feeding stand

A folding stand of 0.9 mts height, made of wood are used to place the removed trays from the stand for feeding and bed cleaning. Same equipment with different height, adjustable heights and revolving types have been introduced in the field

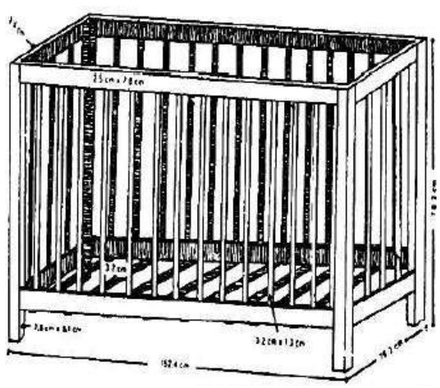
(m) Bed cleaning nets

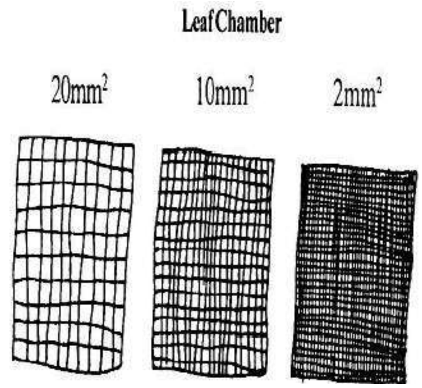
Nets of different mesh size (2mm, 10 mm and 20mm) made of cotton or nylon thread is used for different stages of the silkworm. They are used for cleaning the rearing beds and at least two nets are required for each rearing tray.

Using of bed cleaning nets is advantageous in preventing direct handling of larvae, which facilitates proper maintenance of hygiene resulting in their healthy growth. Now these are used only in chawki rearing (Fig.3.4)

(n) Leaf chamber

A rectangular chamber made of wooden reapers with a size1.5mt long, 0.9mts wide and 0.8 m of depth is used to store harvested mulberry leaf or shoots. Wet gunny cloth is covered on all sides of the leaf chamber. Water is sprinkled periodically on the gunny cloth to keep the leaves inside the chamber fresh.





Bed cleaning net

Leaf chamber **Fig. 3.4. Rearing Equipment**

(o) Mountages

The equipment used for supporting the larvae when they spin their cocoon are called mountage. There are different types of mountages based on the availability of local material, cost, convenience of storage, drying etc. At present new modern devices used for better results.

1.Chandrika: It is an old traditional method, which is made up of bamboo is most popular in south India. This consists of a bamboo mat of size 1,8 X 1.2mt supported by a split bamboo reapers on all sides. On the bamboo mat, a bamboo tape of 4-5cm width is wounded in a spiral manner. It accommodates about 1,000—1200 worms for cocoon spinning.

2. plastic collapsible mountage: Popularly used to mount silkworms in large scale rearings, which is quite convenient method in shoot rearing, where in the ripened worms crawl on to these plastic mountages spread on shoots and start spinning immediately without wasting silk.

3.**Rotary mountage**: The advanced mountage is rotary mountage which gives best results in mounting process. (Fig. 3.5)

Straw mountage and bottle brush montages are also used in small scale rearings.

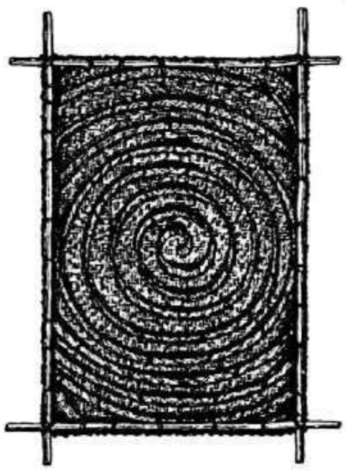


Fig. 3.5 Chandrika **Rotary mountage**

Fig. 3.6 Plastic collapsible mountage

(p) Hygrometer: Equipment used to record humidity in the rearing tray.

(q) Wet and Dry thermometer:

Equipment used to measure both wet and dry temperature and relative humidity and calculated based on these readings by using standard table

Fig.3.7 Dial Hygromete

Fig.3.8 Wet and Dry thermometer

Relative Humidity (%)

Dry-Bulb Temperature (°C)	Difference Between Wet-Bulb and Dry-Bulb Temperatures (C°)															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
−20	100	28														
−18	100	40														
−16	100	48														
−14	100	55	11													
−12	100	61	23													
−10	100	66	33													
−8	100	71	41	13												
−6	100	73	48	20												
−4	100	77	54	32	11											
−2	100	79	58	37	20	1										
0	100	81	63	45	28	11										
2	100	83	67	51	36	20	6									
4	100	85	70	56	42	27	14									
6	100	86	72	59	46	35	22	10								
8	100	87	74	62	51	39	28	17	6							
10	100	88	76	65	54	43	33	24	13	4						
12	100	88	78	67	57	48	38	28	19	10	2					
14	100	89	79	69	60	50	41	33	25	16	8	1				
16	100	90	80	71	62	54	45	37	29	21	14	7	1			
18	100	91	81	72	64	56	48	40	33	26	19	12	6			
20	100	91	82	74	66	58	51	44	36	30	23	17	11	5		
22	100	92	83	75	68	60	53	46	40	33	27	21	15	10	4	
24	100	92	84	76	69	62	55	49	42	36	30	25	20	14	9	4
26	100	92	85	77	70	64	57	51	45	39	34	28	23	18	13	9
28	100	93	86	78	71	65	59	53	47	42	36	31	26	21	17	12
30	100	93	86	79	72	66	61	55	49	44	39	34	29	25	20	16

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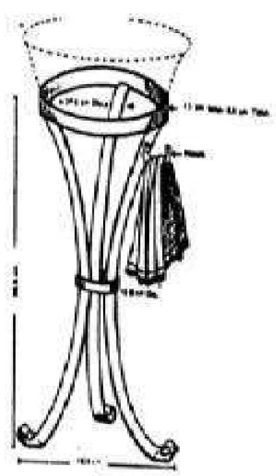
Fig. 3.9 Chart to calculate Relative humidity in rearing room

Fig. 3.10 Shoot Rearing Equipment

(r) Sprayer: Normally formalin solution of 2% is used for disinfection of rearing house and rearing equipment, a sprayer to spray any disinfection solution either hand or power operated is needed.

Other equipment: like humidifier to raise the humidity, an oven or stove to warm up the rearing room, a floor mat soaked in formalin kept at the door to prevent germs entering the room and a wash basin to wash hands those who operate the rearing activities.



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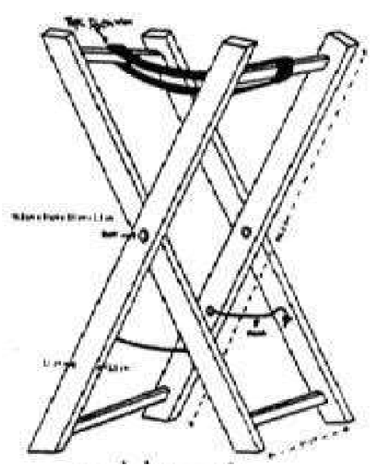

Feeding stand

Fig. 3.11 Rearing Equipments

Chemicals used for disinfecting the rearing house:

Thorough disinfection is must before and after completion of silkworm rearing for successful crops. The microorganisms like bacteria, virus and fungus causes various disease to silkworm during rearing. To control these diseases spraying disinfectants like formalin, bleaching powder, chlorine dioxide is very effective and bed disinfectants like Resham keet oushad (RKO), Uzicide, China clay, Dimiline and DthaneM45 or Capton and Lime powder also are used.

Mechanization for large scale rearing:

Sericulturally advanced country like China is well known for mechanization, where they have been taking up large scale mulberry and silkworm rearings to reduce cost of production. Small scale rearings are suitable to small land holding farmers, but where ever possibilities are there, largescale farming is best method to earn considerable income. In recent periods with the evolution of new techniques and mechanization in silkworm rearing, Indian farmers are also coming forward to take up large scale and corporate farming.

Mechanization is usage of different types of machines to take up day to day works in mulberry production and silkworm rearings, which reduces cost of mulberry and cocoon production to 25% comparing to manual methods ie., more than 40%. Different machines are developed by CSR&TI and other organizations. China and Japan already advanced in using machines to overcome not only the labor problem but also for perfection and quality production.

Mechanization in mulberry and cocoon production:

- **Mulberry cutting or leaf chopping machine** is very much useful in making mulberry cuttings and chopping leaves for chawki rearing.
- **Use of tractors** for inter cultivation, application of fertilizers, and manures is possible in large plant spacing systems like paired row and tree plantation, which not only reduces

labor cost but also time saving to produce quality mulberry leaf.

- **Power jet sprayers** attached to tractor also saves time and labor in spraying growth regulators and other disinfectants.
- **Shoot cutter or pruner** is very much useful in harvesting shoots for fresh leaf feeding to silkworm in shoot rearing method.
- Shoot feeding in large scale rearings is done by mechanized **shoot feeder**, which is also a time and labor saving device.

- **Mechanized dusters** for dusting various disinfectants of uniform quantity during silkworm rearing is also time and labor saving method.
- **Cocoon harvester** is used to harvest the cocoons from the plastic collapsible and rotary mountages.
- **De-flosser** is used to de-floss and cleaning the cocoons after harvesting from mountage to fetch good prices in the market.

Summary

- Rearing equipment must be simple, easy to handle, available at a low cost and should be convenient for disinfection.
- Bamboo trays and chandrika, are popular and suitable for small scale rearings and in large scale rearings are replaced plastic collapsible mountages.
- Paraffin paper, foam rubber strips are important in regulating temperature and humidity during chawki rearing.
- Leaf chamber covered with wet gunny cloth used to preserve harvested leaves as it is done twice in a day.

- As a part in maintenance of hygienic conditions chopsticks, bed cleaning nets in chawki rearing, formalin mat, wash basin stands are used
- Rotary mountage is advanced and best for harvesting good quality cocoons.

Short Answer Type Questions

1. What is the importance of ant well?
2. What are the advantages shoot births?
3. Name any four equipments used in chawki rearing.
4. Mention any four mountages used in rearing.
5. Write different sizes of bed cleaning nets used in rearing.
6. What are the chemicals used in disinfection ?
7. Mention leaf storage equipments required for rearing.

Long Answer Type Questions

1. List out the rearing equipments and explain six important equipments used in chawki rearing.
2. Describe few rearing equipment used in late age with neat sketches?
3. Write about disinfectants and chemicals used in rearing.
4. Draw neat labelled diagrams of the following equipment and mention their uses.

   (a) Antwel (b) Chop stics (c) Rotary mountage

5. (a) plastic mountage (b) Leaf chamber (c) shoot births

UNIT 4

Preparation for Rearing

Structure

Learning Objectives

- To understand the importance of cleaning
- To know about the various disinfectants used in silkworm rearing
- To know preparation of disinfectants for disinfection of equipments and rearing house.
- To know how to maintain the hygienic conditions for ideal rearing and record maintenance.

4.1 Introduction

The important step for every successful rearing is disinfection. Disinfection of rearing room and equipment before starting and after completion is compulsory to have disease free silkworm rearings. which aims at destruction of disease causing microorganisms present in the rearing room and surroundings. The diseases which are very common during rearing are caused by bacteria, viruses, fungi and protozoa. These pathogens released by diseased silkworms easily accumulate and spread in the rearing environment through different routes. The accumulation of pathogens is very common in rearing houses because of regular and largescale rearing crops. The spread of micro pathogen is through unhygienic conditions during rearing, per ‘os (orally) while feeding and through injuries caused during rearing and some pathogens transmit from parents to offspring through egg (Hereditary). Therefore, some preventive and control measures must be followed for successful crop harvest.

4.2 Cleaning

This process of cleaning must be done prior to disinfection. The rearing room and surroundings have to be thoroughly swiped without any dust and dirt All the accumulated junk, debris diseased and dead larvae should be collected and burnt out. If there is stagnation of water, it has to be drained to avoid the multiplication of microorganisms. All the crevices and holes in the rearing room should be closed. The ceiling and walls of the rearing must be cleaned. The rearing room and appliances have to be washed thoroughly with water and dried under sun. In case of Chandrika, the waste attached to mountage is burnt with match stick or gas flame.

4.3. Disinfection methods

The destruction or deactivation of disease causing germs is called disinfection.

Methods of disinfection

Disinfection may be carried out by both physical and chemical methods. The most effective and simple method of disinfection is by using chemicals i.e. disinfectants. Disinfection must be conducted before starting and completion of rearing.

(A) Physical method

a. **Sun drying:** The rearing appliances are exposed to direct sunlight for disinfection. Some pathogens are killed or deactivated at 40 to 45° C. This is effective and cheap method useful to disinfect rearing equipment but not the rearing room.

b. **Steaming:** Steam is a good sterilizing agent. It can be successfully used for disinfecting the rearing room and its appliances. But initial cost of installation of steam generator is high.

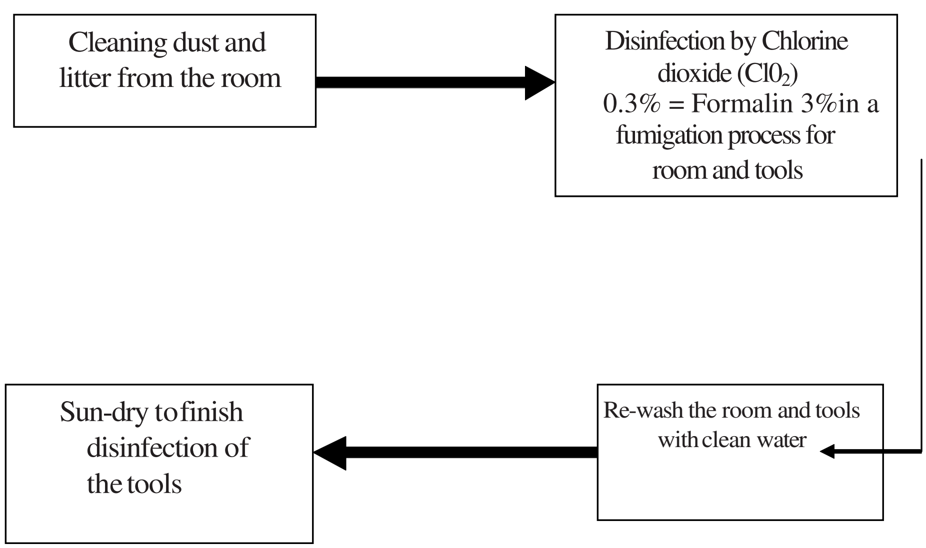

Fig. 4.2. Disinfection Procedure

(B) Chemical method

The most commonly used disinfectants in sericulture are Formalin, bleaching powder, slaked lime and chlorine dioxide. The effectiveness of disinfectants depends on three factors namely concentration, duration of treatment and room temperature at the time of disinfection

a. Formalin: Commercial formalin contains 30 to 40% formaldehyde and has a specific gravity of 1.081 to1.087. Its effectiveness is due to the reducing property of formaldehyde, which reduces by accepting an oxygen atom from the germ cells and get converted to formic acid, there by the germ cells become inactive. The disinfecting action of formalin is stronger at higher temperatures (above 25ºc) and more than 70% humidity.

All the rearing equipment and room must be sprayed on all sides thoroughly and kept within the sprayed room for same time. After disinfection, the rearing room is kept doors closed for 15-20 hrs and then washed with water to remove the smell of formaldehyde and tools are dried under sun.

b. Bleaching powder: It is a white amorphous powder with a pungent odour of chlorine. Commercial grade bleaching powder contains about 25- 30% chlorine. The action of bleaching powder is optimal under wet and contact conditions and therefore, the surface of equipment and walls should be drenched with this solution. HOCl and HCl and nascent oxygen released has a strong oxidizing power against pathogens, Cl_2 has bactericidal action and Ca++ ions are effective on viruses and alkalinity of bleaching powder solution acts as germicidal agent.

c.Slacked lime (calcium hydroxide): Slacked lime is a very useful disinfectant in sericulture, especially against virus which absorbs moisture and can be used as bed disinfectant.

d. Chlorine Dioxide: Chlorinedioxide (ClO_2) marketed in different trade names such as Sanitech, Sericol etc., is an ideal disinfectant in sericulture. The disinfectant available at 20,000 ppm concentration is a strong oxidizing agent. Chlorine dioxide 2.5% concentration in combination with 0.5% slacked lime is effective in all silkworm pathogens. It possesses tolerable odour and least corrosive at the suggested concentration.

(e) Disinfection of rearing house and appliances : The required quantity of disinfectant (1.5 L/Sq.m or 0.140 L/Sq. ft. floor area of the rearing house +10% floor area of the rearing house +10% for outside the rearing house +25% of disinfectant solution for tray rearing) sprayed using powerful jet sprayer uniformly to drench all parts of rearing house inside and outside and appliances.

The rearing equipment such as rearing trays, feeding stands, basins, ant wells etc, which are smaller in size and easier to handle are best disinfected by dipping them for 10 minutes in a tank containing 5% bleaching powder solution. The bigger equipment i.e. stands, chandrika, leaf chamber etc. are disinfected by spraying 2.5% of ClO_2 in 0.5% slacked lime or with 2% formalin in 0.5% detergent solution.

Disinfection in the gaseous form is called fumigation. Formalin is used for this process. The quantity of original formalin solution required for disinfection is calculated according to the room size. The solution is boiled and allowed to evaporate in a pan and vapor coming out slowly reaches all crevices and corners of equipment and room and kills the micro germs.

Fig:4.3 Disinfection of Rearing House & Equipment

Precautions:

1. The process of spraying and fumigation has to be done at raising temperature (25°c) around 11a.m for better disinfection.
2. Disinfection rearing house has to be done in air tight condition along with

equipment.

3. In fumigation process care should be taken so that chemical does not catch fire, nullifying the disinfecting effect.

4. Rearing house should be closed after disinfection at least for one day. All the doors, windows are opened 1-2 days before use of rearing house to allow free circulation of fresh air.

4.4 Preparation of disinfectants

For preparing required strength Formalin the following methods are used**.**

First method

$$\text{Required strength formalin} = \frac{\text{Strength of original formalin} - \text{strength of formalin required.}}{\text{Strength of formalin required}}$$

Second method

$$\text{Formalin required} = \frac{\text{Required Quantity of concentration} \times \text{required quantity of solution}}{\text{Available concentration of commercial formaldehyde}}$$

Model problem

Calculate the required 2% formalin solution and also the required amount of commercial Formalin for disinfection of rearing house of 6 x 9m with 4mts height and terraced roof

Solution

The required 2% formalin for disinfection of rearing house of 100sq.mt.area is about 5.73lts. This is calculated as follows.

1. Floor area = length x breadth
2. Area of 2 walls = length x height of each wall x 2
3. Area of 2 other walls =breadth x height of each wall x 2
4. Roof of terrace =length x breadth

To disinfect 6x9m with height of 4mts size room, the required 2% formalin is calculated.

Floor area = 6x9mts =54mts2 or (20’x30’) =600sqft.

Area of 2 walls = 6x4x2mts =48mts2 or (20’x10.3’x2’) =412sqft

Area of 2 walls =9x4x2mts =72mts2 or (30’x10.3x2) =618sqft.

$$\text{Total area} = \frac{\text{Area of roof} = 6x9\text{mts} = 54\text{mts2 or } (20'x30') = 600\text{sqft.}}{228\text{sqmts or } 2230\text{sqft}}$$

$$\text{Requirement of 2\% solution} = \frac{228 \times 5.73}{100} = 13.06 \text{ liters}$$

For disinfecting the rearing room 13.06 liters of 2% formalin is required. Additionally, equal amount of solution is required for rearing equipment.

Total requirement of 2% formalin is 26 liters.

$$\frac{40 - 2}{2} = \frac{38}{2} = 19 \text{ liters}$$

1 liter commercial formalin is to be added to 19 liters of water to get 20 liters of 2% formalin.

To get 26liters of formalin.

$$\frac{26}{20} = \frac{13}{10} = 1.3$$

About 1.3liters of commercial formaldehyde is required to disinfect rearing equipment and rearing house(6x9x4mts) which can accommodate 250- 300 dfls.

Second method

$$\frac{2x100}{40}$$

$$\frac{2000}{40} = 50 \text{ cc of commercial formalin}$$

To calculate quantity of formalin requires is

$$\frac{2x26}{40} = \frac{52}{40} = 1.3 \text{ lit}$$

1.3 liters of commercial formalin required.

The prime aim of maintaining hygiene in the rearing place and premises is to prevent the entry of pathogens from a wide range of external sources during period of rearing after disinfection.

4.5 Maintenance of hygienic conditions and records

1. Disinfection of rearing house and equipment is a must before starting rearing.
2. Clean hands with 2% Formalin and foot mats wetted with Formalin are used before entering rearing house.
3. Restrict the entry of persons in the rearing house especially during chawki rearing.
4. Collect dead worms during rearing and periodically check and separate diseased and unequal worms immediately and dispose them in a vessel containing 5% bleaching powder in slaked lime solution.
5. Cleaning of rearing bed must be done regularly up to 3^{rd} moult as per recommendation with the help of net, bed waste should be decomposed in a pit.
6. Avoid borrowing the rearing appliances. Do not use appliances without disinfection.
7. The compost pit should be away from the rearing house.

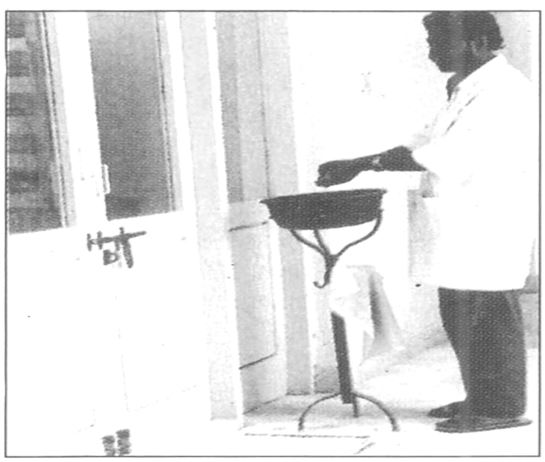

Fig. 4.4 Maintenance of Hygiene

Maintenance of rearing records:

For smooth administration of silkworm rearing proper record maintenance is required. Day to day activities are recorded by following perfect schedule. Every activity is recorded to understand the success or failure of crops and to calculate the economics of each rearing, which helps to reduce unnecessary costs incurred.

a) **Equipment record:** All the rearing equipment, its cost and its maintenance are recorded**.**

b) **Eggs or chawki worm record:** All the details regarding date of hatching, race, number, address of supplier etc, to be recorded for calculation of hatching percentage, Leaf cocoon ratio (LCR).

c) **Feeding record:** Details of time of feeding, quantity of leaf/feeding/day/ instar to be recorded.

d) **Temperature and Humidity record:** Temperature and Relative humidity should be controlled to optimum level.

e) **Bed disinfectants:** Time and day of dusting different disinfects to be recorded.

f) **Pebrine and other diseases record:** Frequency of disease incidence and loss of crop percentage to be recorded remedial manner

g) **Moulting record:** Time and duration of each moult to be recorded.

h) **Spinning record:** Time, date duration spinning, harvesting, total weight of cocoons harvested, and its cost to be recorded.

i) **Expenditure record:** Expense incurred to complete the crop, like labor, disinfectants, electricity, transport and miscellaneous expenses has to be recorded to calculate net profit from the crop after selling the cocoons in the market.

Summary

- Preparation of rearing house is must before starting rearing.
- Cleaning of dust and dirt in and around the rearing room is ensured. All the crevices and holes should be concealed before disinfection.
- Disinfection process is done with chemicals like formalin, bleaching powder, slaked lime, chlorine dioxide so on.
- Equipment are dried under Sun after dusting and before disinfection.
- 2% Formalin is used for spraying, 5%bleaching powder, 0.5% of slaked lime and Chlorine dioxide is used for disinfection.
- Required and strength quantity of disinfectants is calculated according to the room area.
- Fumigation process is effective and total disinfection is achieved simultaneously.
- Slaked lime is very useful disinfectant in sericulture, especially against viruses.
- Maintenance of hygienic conditions checks the spread of diseases

Short Answer Type Questions

1. Define disinfection.
2. What is disinfectant and give examples?
3. Define fumigation.
4. Name any four disinfectants used in sericulture.
5. What is Sun drying of equipment?
6. Write the principle to calculate required strength of Formalin.

7. How do you disinfect small rearing equipment?

8. What is the ideal temperature and time for disinfection?

9. Mention the precautions to be taken during disinfection.

Long Answer Type Questions

10. What is the purpose of hygienic conditions inside the rearing room?
1. What is disinfection and detail the process of disinfection?
2. Write about different record maintenance in silkworm rearing.
3. How the process of disinfection of rearing house and equipment is done?
4. Write in detail about the process of fumigation.
5. Maintenance of hygienic condition in rearing is important, justify the statement

UNIT 5

Environmental Conditions

Structure

Learning Objectives

- To understand the effect of environmental conditions on silkworms
- To understand the regulation of environmental conditions for ideal growth of silkworm

5.1 Introduction

During silkworm rearing the environmental conditions like temperature, humidity, light and air current will have a remarkable influence on the growth of the larvae and ultimately on cocoon crop quality. However, their influence varies at different stages of growth. Hence it is necessary to provide the optimum climatic conditions required at different stages of silk worm rearing.

The different environmental conditions and its effect on silkworm during its development, particularly temperature, humidity, air and light are detailed in this chapter.

5.2 Temperature

Silkworms are Poikilotherms, thus the temperature has direct impact on the various physiological activities of silkworm i.e. metabolic rate, activity of enzymes, nutrients conversion, digestion and assimilation, excretion, nervous stimulations and hormonal actions.

The silkworm can grow in temperature between 15ºc to 40ºc. But in view of its effect on the physiology of silkworms it is divided into three groups.

A. Temperatures between 20º-28ºc is harmless to the growth of silkworms. But higher or lower than this range is harmful to the physiology of silkworms which deteriorates larval health.

B. Temperatures between 24-25ºc for late age and 26-27 ºc for chawki worms.is favorable for the healthy growth of silkworm.

C. Temperatures between 26º—28ºc is favorable for spinning cocoons resulting in good cocoon productivity.

The temperature in the early instars should be relatively higher (26-27 ºc) than during later instars, decrease in temperature will retard physiological activities and worms do not feed on mulberry leaves leading to starvation and the worms become weak, there by susceptible to diseases resulting poor quality. Incase sufficient nutritive mulberry leaves are not given to silkworms, high temperature effects on physiology there by injuring the health leading to poor quality cocoons.

In case of late age silkworm require little lower temperatures (24-25ºc) than chawki age, which activates the physiological activities and feed actively on leaves so that the growth will be uniform and acquires tolerance to various diseases. At spinning temperature between 26º—28ºc is required for quick drying of filament coming from spinneret during spinning, leading to quality spinning of cocoons.Temperature in the rearing house is measured by thermometer.

The ideal temperatures of rearing silkworms in different instars are as follows

Age	Optimum temperature °C
I	26 - 28°C
II	26 - 28°C
III	24 - 26°C
IV	24 - 25°C
V	23 - 24°C

5.3 Humidity

The optimum humidity conditions required for ideal rearing of silkworm are 70 – 80 %, like temperature, humidity required at chawki is also higher ie.,75– 80%, but late age worms require little lower ie., 70- 75%.. High humidity causes reduction in the growing period of silkworms by accelerating the physiological activities, whereas low humidity leads to prolongation of the growing period. Expiration of CO_2 increases with rise in humidity. The combined effect of both temperature and humidity largely determines the growth of silkworms which leads to quality cocoon production.

The role of humidity is both direct and indirect, influencing physiology, rate of withering respectively. Therefore, suitable rearing must be determined by considering by following points.

(A). The early instars of silkworm are resistant to high humidity with relatively little or no effect change in the moisture.

(B). The low humidity or dry conditions in rearing room leading to quick drying of leaves, silkworms cannot eat dried leaves.

(C). If the humidity is high in the air of rearing room leads to outbreak of pathogens and their growth, thus silkworms suffer from diseases.

Considering the above, the following different humidity conditions must be maintained.

Age of worms	humidity%
I	80
II	80
III	80
IV	75
V	70

The humidity in the rearing room is recorded by using hygrometer or wet & dry bulb thermometer.

5.4 Air

The silkworm rearing house constructed with sufficient ventilation, to receive fresh air during rearing. Accumulation of various gasses like CO2, Ammonia, SO_2 etc, are common due to respiratory activities of silkworm, litter, preserved leaf and disinfectants used for disinfection. These gasses create problem to silkworm during its growth, leads to formation of inferior cocoons and poor production. The safe limit for these gases in silkworm rearing is CO_2 1 -2%, formaldehyde gas 1%, SO_2 0.02%, and ammonia 0.1%. The young silkworms are less resistant to toxic gases, as the production of these gases is comparatively less during younger stages than during later instars.

5.5 Light

Light has little influences on the health and survivability of silkworm, but influences the distribution of the larvae in the rearing bed. Silkworms are fond of dim light (15-30 lux) and avoid strong light and darkness.

The appetite of silk worm is more in a bright place than in a dark place. The larvae come up more quickly under light condition than in dark condition. Longer photoperiod during early instars greatly affects the hibernating character in the next generation as 18 Hrs. photoperiod per day is found optimum for silkworms. When the silkworms are reared under such conditions the weight of cocoons and cocoon shell become heavier than those reared under dark condition

5.6 Regulation of environmental conditions

The environmental conditions vary from season to season and place to place. Its regulation during silkworm rearing is so necessary to maintain optimum conditions of temperature, humidity and other conditions like light and air required by silkworm for its healthy growth.

During winter when the temperature is low, it is raised by keeping electric heater or oven or charcoal stove. Besides this the doors and windows are kept closed during nights and opened during day when temperature is optimum which also regulates light and air flow. Regulation of humidity for young age rearing is achieved by adopting box rearing or by paraffin papers and wet foam pads surrounding the rearing bed. During summer when humidity is low, is raised by using humidifiers.

Whereas in the tropical conditions where temperature almost above 35ºC, rearing house is so designed with high roofs and good ventilators to control higher temperatures to some extent and by ensuring adequate ventilation for light and free circulation of air inside the rearing house. The temperature is quite opposite in summer when compared to winter and rainy seasons. The hanging of wet gunny cloth to doors and windows also brings down the temperature and maintain optimum humidity. Use of air coolers or air conditioners also regulates temperature and humidity, which are expensive, and are suitable for large scale rearings.

Sufficient number of windows and ventilators should be provided in the rearing houses for better results, which not only circulates fresh air but also regulates temperature and humidity. Chawki worms are more susceptible to toxic effect. Air current of 1.0 m/sec during V age rearing reduce the larval mortality and improves ingestion, digestibility, larval weight, cocoon weight and pupation rate compared to those recorded under poor ventilation condition.

Therefore, maintenance of optimum conditions in the rearing is much needed for maintaining healthy conditions of worms, which leads to uniform growth and good cocoon production.

Summary

- The ecological factors chiefly temperature, humidity, light and air during rearing have a significance influence on the growth of larva and ultimately on crop yield and quality.
- The influence of these factors on rearing varies in different stages of larval growth.
- Temperature directly influences the growth of the worms. The ideal temperature ranges from 24 -28ºC.
- The effects of humidity are direct and indirect, optimum humidity ranges from 70 -85% for better growth of silkworms.
- Chawki worms need high humidity, this is possible when paraffin paper, wet foam pads and box rearing is adopted.
- High humidity generally helps to prevent leaf withering and improves feeding capacity of silkworm.
- Silkworms are delicate and sensitive. Fresh air is needed for healthy growth.
- Silkworms are fond of dim light of 15 to 20 lux and avoid strong light and

darkness.

Short Answer Type Questions

1. Define poikilotherms.
2. What is the ideal temperature for silkworm rearing?
3. How do you regulate high temperature during summer?
4. How do you regulate low temperature during winter days?
5. What are the indirect effects of humidity?
6. How do you measure humidity in rearing tray and rearing house?
7. List out toxic gases produced in the rearing room.
8. What is safe limit of CO_2, NH_4, and SO_2 in rearing?
9. How much air current is useful in V instar?
10. How much light is required for rearing?

Long Answer Type Questions

1. Discuss in detail about the influence of temperature and humidity on silkworm growth.
2. How the air influences the growth of silkworm.
3. Write on the role of light on the growth.
4. Explain the regulation of temperature and humidity during silkworm rearing.

UNIT 6

Economics of silkworm rearing

Structure

Learning Objectives

After studying this unit, the student will be able

- To know the list and quantity of rearing equipment's required for rearing 300dfls
- Understand the economics of shoot rearing and chawki rearing
- To understand the importance of by-products of silkworm rearing and their utilization

6.1 Introduction

After selection of rearing house, the equipment required for accommodation of silkworm rearing must be known. The rearer must utilize all the resources available in the field for procurement/preparation of equipment. Usually the equipment is procured as per the method of rearing, local availability, cost of equipment, convenience for disinfection so on.

Presently with adoption of new technologies all the rearing requirements were improved resulting better crop quality and yield. New improved bivoltine hybrids need more space and leaf, hence all the requirements vary accordingly. For rearing 100dfls 400 square feet bed area is required.

Establishment costs of mulberry garden (First year)

Sl. No.	Particulars	Value (Rs.)
1	Ploughing operations tractor (4hr) @Rs 600.00/hr	2400.00
2	Final land preparation (2hr) @ 600.00/hr	1200.00
3	Farm yard manure (8 tones) @ Rs.500/T.	8000.00
4	Mulberry plants- 6000 saplings @ Rs.1.00/sapling	6000.00
5	Making trenches with tractor (4hr) and planting @ Rs. 600.00/hr	2400.00
6	Fertilizer (100 kg Ammonium sulphate; 125 kg Single super phosphate and 35 kg Murate of photash)	1036.00
7	Fertilizer application charges	600.00
8	Irrigation	1500.00
9	Hoeing/Weeding 3 times	1800.00
10	Miscellaneous expenditure	500.00
	Total	25436.00

Maintenance of mulberry garden (II year onwards)

Sl. No.	Particulars	Value (Rs.)
A.	**Operational costs**	
1	Farm yard manure (8 Tons)	8000.00
2	Fertilizer cost @ (600 kg Ammonium sulphate; 300 kg Single super phosphate and 80 kg Murate of potash)	5538.80
3	Manure and fertilizer application	1200.00
4	Irrigation water cost	5000.00
5	Irrigation	3600.00
6	Weeding	3400.00
7	Shoot harvest	7200.00
8	Pruning and cleaning of plants	600.00
9	Land revenue	50.00
10	Miscellaneous	500.00
11	Interest on working capital	621.78
	Total variable cost	**35709.78**
B.	Fixed costs	
	A portion cost of establishment of mulberry garden	1695.73
	Total leaf production (20000) Kgs cost	**37405.51**
	Total cost/kg of leaf	**1.87**

Building and rearing assets for 300 DFLs

Sl. No.	Rearing building/equipment	Number / Quantity required	Rate (Rs)	Value (Rs)
	BUILDINGS			
1	Late age rearing house including Chawki and shoot store room(sq. ft)	1300	250.00	325000.00
2	Veranda (Sq.ft)	300	50.00	15000.00
	Total			**340000.00**
	Equipment			
1	Power sprayer	1	6000.00	6000.00
2	Mask	1	2000.00	2000.00
3	Room heater	3	750.00	2250.00
4	Humidifier	3	1500.00	4500.00
5	Gas flame gun	1	500.00	500.00
6	Egg transportation bag	1	150.00	150.00
7	Chawki rearing stands	2	500.00	1000.00
8	Wooden rearing trays	24	150.00	3600.00
9	Feeding stands	1	100.00	100.00
10	Leaf chopping board	1	250.00	250.00
11	Knives	1	50.00	50.00
12	Leaf chamber	1	1000.00	1000.00
13	Ant well	42	25.00	1050.00
14	Chawki bed cleaning nets	48	20.00	960.00
15	Litter basket / Vinyl sheets	2	250.00	500.00
16	Plastic basins	2	50.00	100.00
17	Leaf collecting basket	2	50.00	100.00
18	Shoot rearing rack (45 ft X 5 ft, 4 tier)	2	1500.00	3000.00
19	Nylon net	1	1500.00	1500.00
20	Rotary mountage	105	240.00	25200.00
21	Plastic incubation frame	6	50.00	300.00
22	Plastic buckets	2	50.00	100.00
	Total			**54210.00**
	Grand total			**394210.00**

Sl.No	Particulars	Cost/revenue
A.	**Variable Costs**	
1	Leaf	37405.00
2	DFLs (1500 DFLs)	4200.00
3	Disinfectants	7425.00
4	Labour (@ 25 MD/100 dfls)	16875.00
5	Transportation and marketing	1580.00
6	Other costs	500.00
7	Interest on working capital	305.80
	Total variable costs	**68290.80**
B.	**Fixed costs**	
	Depreciation on building and equipment and interest on fixed costs	26820.00
	Total costs	**94572.26**
C.	**Revenue**	
	Cocoon yield	60.00
	Average cocoon price	300.00
	Cocoon production	900.00
	Income from cocoon	270000.00
	Income from by-products	5400.00
	Total revenue	**275400.00**
	Net revenue	180827.74
	Benefit: cost ratio	**1.33**

Source: ***Central Sericulture Research & Training Institute, Mysore***

Note: *The costs given in above table may vary according season and place*

Economics of Chawki worm Rearing

Self-sustainable models of Commercial Chawki Rearing Centres

Sl. No	Details	2-acre model (5000 DFLs / batch)
1.	Mulberry garden required	2 acres (4 plots)
2.	Variety to be planted	V 1 or S 36
3.	No. of crops harvested/plot /year	8 harvests
4.	Leaf required / year	28 – 30 MT
5.	Chawki rearing / house required	42'x30'x16'
6.	No. of crops to be reared / year	32
7.	Total no. of DFLs to be brushed /year	1,60,000
8.	Man days required / year	1024
9.	Supervisor	One

Sl. No	Details	2-acre model (5000 DFLs / batch)
1.	Total mulberry acre to be covered by CRC	130-150 acres
2.	No. of beneficiaries	80-100 farmers
3.	No. of DFLs / batch	5,000
4.	No. of beneficiaries / batch	18-20
5.	No. of acres covered / batch	20-22
6.	No. of batches / year	32
7.	No. of DFLs / year	1,60,000
8	Average cocoon yield / 100 DFLs	65-70 kg
9	Bivoltine cocoon production / CRC	10,40,000 kg
10	Bivoltine silk production / CRC/year	14-16 MT (@ 6.5 Renditta)

	Total expenditure (A+B)	**3,86,000**
II	**INCOME**	
1	Income from sale of chawki worms @ Rs 300/100 DFLs	4,80,000
	NET INCOME / YEAR	**94,000**
	Gross income /100 DFLs of chawki reared worms	300
	Expenditure /100 DFLs	241
	Net income / 100 DFLs	59
III	**Benefit Cost Ratio**	**1: 1.24**

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6.2 By products from Silkworm rearing:

The area under mulberry during 2016-17 is around 2.21 lakh hectares producing 1,62,779 metric tons of cocoons with a raw silk productivity of 97.30 Kg/Ha. It is estimated that 168.86 lakh tons of by product in terms of rearing waste is available from the present mulberry growing area.

Value addition to By-products at Sericulture farm level:

Mulberry and silkworm are exploited so far only for silk production in India. If sericulture industry needs to be kept alive in all parts of India, wastes generated during all sericulture activities can very well be converted in to valuable products of industrial value. Thus, in the whole cycle, a substantial quantity of residual mulberry leaves, unwanted silkworm larvae, pupae, moths and silk are available as by-products for utilization.

1. Mulberry production:

In modern era apart from using mulberry leaf for silkworm rearing activity search for alternative uses have been explored and documented because of highly nutritive with medicinal properties.

a. Mulberry in human consumption:

Herbal mulberry tea preparation: Mulberry tea is a natural, caffeine-free drink that is packed with vitamins and minerals and is used to prevent and treat many health conditions, including cold symptoms, weight loss, blood vessel problems and diabetes. Mulberry tea leaves contain 25 times more calcium than milk. Not only that, they have ten times more iron than spinach, and over twice the fibre of green tea. No wonder it was used in China for thousands of years as a medicinal herb. Acceptance was for herbal tea prepared with Mulberry tea powder (20g), sugar (40g), Ashwagandha (2g), Mint (2g) in one litre of water brewed for 4 minutes.

Leaf curry, Pakoda, flakes also made from mulberry leaf, chutney made from leaves is in vogue in Manipur (India) and whole leaf papad in Thailand. Left over leaf rearing and garden is good feed for cattle and increases milk production and made to earn additional income.

Mulberry fruits:

In South India, fruits can be harvested in two seasons in a year (October-November and March-May). Whenever mulberry is pruned or defoliated in these seasons, flowering takes place together with sprouting of axillary buds followed by fruit formation. Mulberry fruit contains significant amounts of Vitamin C, dietary fibre, calcium, iron and protein.

Various value addition products from fruit was prepared such Ascandy, traditional wine, pickle, elixir, juice, jam, topping.

2. Rearing waste

a. Compost and Vermi-compost

In sericulture lot of wastes are generated throughout the year due to silkworm rearing and mulberry cultivation. These wastes can easily be recycled in to good organic manure through composting.

Waste cuttings and shoots: Mulberry dried shoots have high calorific value, good fire wood for villagers. It can also be converted in to briquets (Charcoal) for hotels and industries as fuel in boilers.

b. Increased manurial value of digested Biogas slurry by using Silkworm litter

The manurial value of the bio-digested slurry is also increased due to the incorporation of silkworm larval litter. Nitrogen content of the slurry in silkworm larval litter incorporated treatments ranges from 2.01 to 2.67 per cent against 1.65 per cent in cow dung incorporated treatment. Phosphorous content varies from 0.92 to 0.97 per cent and potash content from 1.04 to 1.36 per cent.

c. Livestock maintenance: Sheep/ Goat/Cow/Buffelow/Rabbit rearing.

Mulberry is fast growing and high biomass generating plant, utilization of left over leaves during rearing, side branches, top layer shoot feeding waste is used as animal feed for

Cow/Sheep / goat and feeding small ruminents i.e Rabbit and also using such biomass for preparation of silage and feed. Which improves production of milk and meat efficiently.

Vermi casts: Vermi casts can be used as compost while earthworm biomass as a substitute for proteins, food for the livestock and aquaculture. It is an eco-friendly technology and composting of the sericulture waste can be done quickly. Dried castings can be conveniently packed and sold. The vermi casts also conveniently coated with bio-fertilizers and applied to the field.The quantity of gas produced per gram of total solid destroyed over 6 weeks period is maximum in cow dung + silkworm larval litter incorporated treatment (2,450 cc) compared to 6 cow dung alone (1,910 cc) and silkworm larval litter alone (1,917 cc). Thus, the silkworm larval litter can be used as a supplementary feedstock in biogas production.

Summary

- Rearers should procure good and suitable equipment.
- Usually the equipment are procured as per rearing method.
- New improved bivoltine hybrids need more space and leaf, hence rearing requirements varies.
- For rearing 100dfls 400square feet area is required.

Short Answer Type Questions

1. Mention some feeding equipment.
2. Mention leaf storing equipment used in silkworm rearing.
3. What are the equipment used for regulation of environmental conditions?
4. Mention disinfecting equipment.

Long Answer Type Questions

1. What are the equipment required for rearing 300dfls ?
2. Write the model economics of rearing.
3. Write about by products of mulberry and silkworm rearing.
4. Write about model economics of chawki rearing.

UNIT 7

Entrepreneurship Development Programme

Structure

Learning Objectives

- After studying this unit, the student will be able
- Understand the importance of Entrepreneurship Development Programme.
- To know the scope for self- employment in sericulture
- Know about Government schemes and financial assistance.

7.1 Introduction

Entrepreneurship is the "process of the entrepreneur". It is an attempt to create value through recognition of business opportunity. It is basically communicative and management functions to mobilize financial and material resources. Entrepreneurship is also defined as the act of being an entrepreneur, who starts any economic activity for being self-employed.

An **entrepreneur** is defined as "person in effective control of commercial undertaking; one who undertakes a business or an enterprise". Entrepreneur is an innovative person who maximizes his profits by following new strategies or venturing into new products or services.

The entrepreneurial activity is governed by varying combination of socio-economic, psychological, cultural and other factors.

7.2 Who is Entrepreneur

Entrepreneurial Characteristics:

Being an entrepreneur requires specific characteristics and skills that are often achieved through education, hard work, and planning.

Risk Taker

Businesses face risk. Entrepreneurs minimize risk through research, planning, and skill development.

Perception

Entrepreneurs view problems as opportunities and challenges.

Curious

Entrepreneurs like to know how things work. They take time and initiative to pursue the unknown.

Imaginative

Entrepreneurs are creative. They imagine solutions to problems that encourage them to create new products and generate ideas.

Persistent

True entrepreneurs face bureaucracy, make mistakes, receive criticism, and deal with money, family, or stress problems. But they still stick to their dreams of seeing the venture succeed.

Goal-setting

Entrepreneurs are motivated by the excitement of staring a new business. Once achieved, they seek out new goals or ventures to try.

Hardworking

Entrepreneurs need a great deal of energy to see a venture start and succeed. Yet they are not deterred by the long hours to achieve their goal.

Self-confident

Entrepreneurs believe in themselves. Their self-confidence takes care of any doubts they may have.

Flexible

Entrepreneurs must be flexible in order to adapt to changing trends, markets, technologies, rules, and economic environments.

Independent

An entrepreneur's desire for control and the ability to make decisions often makes it difficult for them to work in a controlled environment.

Need for entrepreneurship

- Increases national production
- Balanced area development
- Dispersal of economic power
- Reinvestment of profit for the welfare of the area of profit generation
- Development is a function of motivation and human resource
- Entrepreneurial awareness

Entrepreneurial Opportunities in Agriculture:

- Diversification:
- Organic farming:
- Food preservation, processing and packaging:
- Production of agro-inputs

Entrepreneurial Opportunities in Sericulture

1. Raising Mulberry saplings (Kisan nursery)
2. CRC's (Chawki Rearing Centres)
3. Egg production and rearing silkworm
4. Vermi - composting

5. Mass production of Parasitoids and Predators
6. Charka, Cottage basin and Multi – end reeling
7. Diversification:
8. Production of various by product

Sericulture in India significantly contributes to create self-employment opportunities, especially rural employment, poverty alleviation, redistribution of income and equity securing towards National economy. The total raw silk productionof 23,060 MT at the end of XI Five year plan registered in annual growth of about 5.5% despite several adverse factors including large scale reduction of mulberry acreage due to drought and urbanization. The Centrally Sponsored Catalytic Development Program (CDP) of Ministry Of Textiles (MOT), Government Of India (GOI) has been able to sustain and strengthen the sericulture activities in the country.

The main objective of the CDP is to improve the productivity in all stages of sericulture to crate gainful employment to rural population by spreading modern and scientific approaches with new technologies of sericulture.

The main areas of sericulture for promotion under CDP are..

- Development and expansion of silkworm host plants (Mulberry)
- Strengthening and creation of silkworm seed multiplication centres and its infrastructure.
- Development of farm and post- cocoon sector
- Upgradation of reeling and processing technologies of silk
- Skill development and enterprise development program (EDP)
- Support for publicity, study/consultancy, crop insurance and health insurance.

While some of the existing schemes are further strengthened and modified with additional inputs and sub- components with new interventions proposed for XII Five year plan are listed below.

- Franchise disinfection program
- Support for construction of rearing houses for Adapted Seed Rearers (ASR).
- Revolving capital fund for state grainages and Registered Seed Producers

(RSP)

- Supporting for development of Kissan Nuseries
- Support for construction Vermi- Compost sheds

7.2 Government schemes

- Support to increase existing acreage and yield through water harvesting method
- Support to construct reeling sheds
- Support for master technicians
- Establishment of Effluent treatment for yarn dyeing and fabric processing
- Subsidy on loan for working capital taken from Banks.

Schemes for financial assistance:

Concerned Department

- Ministry of Textile, Government of India
- Department of Textile & Handloom, Government of Andhrapradesh

Legal Framework

This scheme came into force during IX plan period i.e. in the year 2001-2002 under Ministry of Textile, Government of India.

Eligibility to avail

Any Individual farmers/reelers/weavers or other such entrepreneurs can avail financial assistance under this scheme as per eligibility criteria set for different scheme/components.

Different subsidies extended to sericulture farmers of A.P

S. No	Component	Cost	Subsidy
1	V1saplings	14000-00	10,5000
2	Tree plantation/acre	45,000-00	22,500.00
3	Organic farming(soil enrichment)	10,000-00	5,000-00
4	Model-1 rearing house	2,75,000-00	82,500-00
5	Model- 2 rearing house	1,75,000-00	67,500-00
6	RKVY rearing shed	2,75,000-00	1,37,500-00
7	Varandah	-	22,500-00
8	Rearing shed (SC & ST)	4,00,000-00	3,60,000-00
9	Rearing equipment (SC&ST)	70,000-00	63,000-00
10	Equipments for mechanization	24,000-00	10,000-00
11	Seacaetiur	1400-00	700-00
12	Disinfection	5000-00	3,750-00
13	Chawki rearing house	10,00,000-00	8,00,000
14	Chawki worms	-	750-00
15	Incentive for Cross breeds/Kg	-	10-00
16	Incentive for Bi voltine cocoon	-	55-00

Supportive documents to be submitted

The following documents have to be submitted during applying for financial assistance from Central Silk Board.

- Application form
- Photo copy of the Voter ID
- Photo copy of land documents
- Recent passport size photograph
- Photocopy of bank/postal Pass Book.

Summary

- **Entrepreneurship** is the "process of the entrepreneur".
- An **entrepreneur** is defined as "person in effective control of commercial undertaking; one who undertakes a business or an enterprise".
- Entrepreneur is an innovative person who maximizes his profits by following new strategies or venturing into new products or services.
- The entrepreneurial activity is governed by varying combination of socio-economic, psychological, cultural and other factors
- It is an attempt to create value through recognition of business opportunity

Short Answer Type Questions

1. What is entrepreneurship?
2. Who is entrepreneur?
3. Mention two important characters of an entrepreneur.
4. What is the need for entrepreneurship
5. Mention the opportunities for entrepreneurship in sericulture.
6. Mention financial organizations offering financial assistance.

Long Answer Type Questions

1. What is entrepreneurship and mention in detail about characters of an entrepreneur?
2. What are the financial subsidies offered by Government?

UNITT 8

EDP in Sericulture

Structure

Learning Objectives

After studying this unit, the student will be able

- To know importance of EDP.
- To identify different entrepreneurship development areas in Sericulture

8.1 Introduction

Entrepreneurship (EDP) plays a critical role in promoting the economic growth and development in a country. Growth of entrepreneurship in any sector not only improves production systems and thereby productivity but also strengthens the foundation of the industry by generating opportunities & employment. Keeping this in view, one of the prime focus areas in sericulture sector today is identification of viable seri-business opportunities, encouraging investments in sericulture and promoting entrepreneurship through a variety of methodically planned and designed training programmes.

Central Silk Board and State government is conducting various training programs to encourage farmers and other persons to involve in the establishment and development of different sectors like Kissan nursery, late age rearing of silkworms, chawki rearing, egg production, silk reeling etc.,The Capacity Building & Training Division of CSB, which is an ISO 9001:2008 quality certified training wing, conducts Entrepreneurship Development and other skill & competence enhancement training programmes with focus on Seri-technologies, soft and hard skills. Some of the popular training programmes conducted by this division are organized for influencing potential entrepreneurs to initiate Seri-Business.

8.2. EDP in Mulberry nursery

Kissan nurseries are well known for multiplication of new varieties of mulberry species developed by CSB and other organizations. Whenever there is a demand for new varieties of mulberry, farmers can choose this enterprise to produce large number of saplings on commercial basis to supply the farmers. With this they can earn substantial income and provide employment to few skilled agriculture labours. To start this small enterprise, one should have the basic knowledge of agriculture. Farmer himself who is having few acres of land and water facility can start the production of new varieties of mulberry saplings for commercial distribution.

New method for raising mulberry in nursery

- In sericulture, mulberry saplings are commercially produced from cuttings under raised or flatbed system.

- The success of sprouting and vigour of the sapling are greatly influenced by competing weeds, soil moisture, and soil temperature.

- Since water and labour availability/expenditure on weeding are the hurdles nowadays, a new method of raising mulberry saplings using polythene sheets is developed to overcome these difficulties, which practically proved very effective for successful production of quality mulberry saplings for commercial purpose

- By this method weeds can be totally arrested, as they do not get sunlight.

- Thus, no weeding is required throughout the nursery period (four months), which saves huge expenditure on manual weeding.

- Since there are no weeds to compete with the growing mulberry saplings, they get the maximum soil nutrients, resulting in high vigour and growth, producing quality saplings.

- Unlike other methods, irrigation can be reduced to 50 per cent, as the polythene cover over the soil significantly reduces the soil temperature and prevents water evaporation, thus conserving soil moisture.

- By this method, about 2.30 to 2.40 lakhs saplings can be produced per acre in four months period with an increased average income of Rs. 50,000 over the other methods.

- Net income of Rs 1,78,635 can be earned by producing 2.5 Lakh saplings from 1acre of land.

The following table shows the model economics of nursery of 2.5 Lakh sapling production.

ECONOMICS OF MULBERRY NURSERY
(2.5 Lakh Saplings/acre)

	Work Details	Cost Rs.
1	Plots 8' x 4' size / acre - 1735	
2	195 cuttings / one plot	
3	Total cuttings - 338325	
4	Good cuttings 80% --- 270660	
5	Land preparation expenditure	17650=00
6	Plants & Planting Cost	75150=00
7	Implements Non recurring cost 10,000=00/10 Yrs	1000=00
8	Total cost (SL.No 5+6+7)	93,800=00
9	Cost of production per one Sapling	0.34. p
10	Total income by selling saplings at Rs.1-00	2,70660=00
11	Net income for six months	178635=00

Note: The values given in the above table is only a model, cost may vary from place to place.

8.3. EDP in Chawki Rearing Centres (CRCs)

CRCs are now an integral part of mulberry sericulture and are a vital cog in the sustainability of bivoltine sericulture. Commercial CRCs are being operated by individual entrepreneurs/SHGs/NGOs with the sole objective to produce good quality healthy worms for the farmers leading to better cocoon yields. Today most of the farmers prefer to rear CRC reared chawki worms than brushing eggs on their own. The tremendous growth witnessed in bivoltine raw silk production (3870MT during 2014-15) in the recent years could be attributed to CRC activities and their tribe is increasing day by day. Around 800 CRCs are registered as per Central Silk Board (Amendment 2006) act throughout the country in both mulberry and non-mulberry sectors.

ECONOMICS OF CHAWKI REARING

(5000 Dfls/Batch & 32 Batches/Year =1.6 lakh dfls/annum)

Chawki Rearing Centres (CRCs) location at the places of cocoon pro- duction is gaining popularity and is currently working as backward linkage to the farmers. Several private entrepreneurs are running CRCs in many parts of Karnataka, Tamil Nadu and Andhra Pradesh. Model CRC established at CSRTI-Mysuru lead to the evolution of solid model for economically viable CRC operation. The model economics of CRCs is given in the following tables.

A: Non-Recurring Costs					
Particulars	**Jnit Rate/ Number**	**For 5000 dfls**	**Total Cost (Rs.)**	**Life Span (Years)**	**Depre-ciation (Rs.)**
Rearing House (42' X 32')	600/ Sq.ft	1650	990000	25	39600
Plastic Rearing Trays (2'x3')	480	600	288000	15	19200
PVC Rearing Stands	12000	5	60000	20	3000
Incubation Frames	50	100	5000	15	333
Feeding Stands	200	10	2000	15	133
Chopping Machine	35000	1	35000	20	1750
Litter Baskets	100	10	1000	15	67
Plastic Basins	50	20	1000	10	100
Leaf Collecting Basket	50	25	1250	5	250
Bed Cleaning Nets	50	600	30000	10	3000
Heaters	5000	2	10000	5	2000
Humidifiers	15000	1	15000	10	1500
Power Sprayer	18000	1	18000	10	1800
Disinfection Mask	2000	1	2000	15	133
Thermometer	1000	1	1000	15	67
Interest on Capital					82721
Other Costs					1000
Total: Non-Recurring (A)			**145920**		**75683**

B: Recurring Costs			
Particulars	**Requirement**	**Rate (Rs.)**	**al Costs (Rs.)**
Bleaching Powder (kg)	150		
Sanitech (litre)	120	40	6000

Lime (kg)	250	70	8400
Paraffin Paper (meter)	1000	15	3750
Bed Disinfectant (kg)	115	12	12000
Labour Charges		50	5750
(5 mandays/ 6 days)	1152	232	267264
Cost of Chawki Leaf	35200	15	528000
Cost of Layings	160000	600	960000
Electricity Charges	Lumpsum		18000
Other Costs	Lumpsum		1500
Total Recurring (B)			1762664

Abstract of Costs

Head	Amount (Rs.)
Non-Recurring C00ost (A)	75,683
Recurring cost (B)	17,62,664
Total of (A+B)	18,38,347
CRC owners profit margin @ 10 % of total cost (A+B)	1,83,835
Risk factor @ 5 % of recurring cost (B)	88,133
Total Expenditure per annum (3+4+5)	21,10,315
No. of Dfls brushed per year	1,60,000
Chawki Rearing cost per 100 dfls (6/7) (Rs.)	1319.00

8.3. EDP in commercial silkworm egg production Centre (Grainage)

Egg production (Grainage) is one of the important aspects of sericulture. Therefore, the grainage operations directly reflect on survival rate, life span, growth, and quality of cocoon, etc. The egg production is a technical job, where cross breeds and hybrids are produced systematically under trained technicians and labourers.

At present there is a considerable demand for silkworm eggs because of steady increase in mulberry acreage and silkworm rearings. Initially production of silkworm eggs was done strictly by the Government, later licenses were issued to private people to produce eggs on scientific lines under strict supervision of department of sericulture. So, at present entrepreneurship development in silkworm egg production is very much encouraging.

Entrepreneur must be educated in sericulture or trained in silkworm egg production. Central Silk Board (CSB) is offering skill based short term training courses for persons interested, at the same time providing financial assistance and technical support in establishing commercial egg production centers (Grainages).

At present farmers are directly taking chawki worms from CRCs for their rearings instead of eggs from grainage. There fore all CRCs acquiring eggs from grainages for chawki worm production. Before going to establish commercial egg production centre one must assess or survey the potentiality of requirement of sericulture farmers of that area. Even one can plan for both commercial egg production combined with chawki rearing centre.

Requirements for establishment of commercial Grainage:

- Grainage operations are conducted under supervision of trained skilled staff.
- A well planned building is required to take up different grainage operations. (Reffer grainage model building).
- Different grainage equipment required are procured, its number depends on the quantity of eggs to be produced.
- Seed cocoons are procured based on norms laid down.
- Care must be taken in testing cocoons for Pebrine disease before selecting seed cocoons.
- A strict protocol must be followed in producing eggs and should be on scientific lines, any deviation leads to prosecution of responsible persons under Seed Legislative Act.
- The success of silkworm rearing depends on the eggs produced in a Grainage.
- A systematic recording of all the activities of Grainage will be helpful for future development.
- There are 5 important records that are maintained in the Grainage. Seed cocoon register, Moth Emergence Register, Moth Examination Register, Egg

Production Register, Hibernation and Refrigeration Register are the essential registers for Grainage.

- These registers speak about the economics of the Grainage.

8.2 The following is the example (10 Lakh DFLs) to estimate the economics of grainage

Particulars	Multivoltin	BiVoltine
I. Seed Cocoon cost		
1. Seed cocoons	33.20	
purchased 2 .Bad		16.6
cocoons 20%	0	
4. Percentage of dfls from total seed	6.64	3.32
cocoons(item 3)	26.56	
5. Total dflsproduced		13.2
6. Cost of multi-voltine seed cocoons @ Rs.60	8	
per 1000 cocoons	30%	
7. Cost of bi-voltine seed cocoons @ Rs.80 per	10 lakhs	
700 cocoons		
8. Total cost of seed cocoons(6+7)	Rs. 3.88	
9. Recovery from pierced cocoons	Rs. 0.42	
a. Bi-voltine cocoons 0.533 kg @	Rs. 0.42	
Rs.80 b.Multi-voltine cocoons 0.55	Rs. 0.43	
kg @ Rs.80	Rs. 3.03	
10. Total cost of seed cocoons(8-9)		
II. Expenditure	Rs.	
A. Recurring	0.94	
a. Labour charges	Rs.	
b. Cost of egg sheets	0.08	
c. Cost of chemicals	Rs.	
d. Rent etc	0.08	
e. Transportation of seed	Rs.	
cocoons	0.14	
	Rs.	
f.Miscellaneous	0.12	
B. Non-Recurring		
a. Depreciation on cost of		
equipment	Rs. 0.14	
b. 10 % interest on revolving	Rs. 0.04	
capital Total	Rs. 0.18	
Total cost of layings(Item	Rs. 4.61	
10+a+b) Cost of 100 CB layings	Rs.	
Cost of one dfl	46.00	
	Rs. 460	
	paise	

8.4. EDP in Silk reeling

Reeling industry in India mainly depend on Charaka, Cottage basin and Multi end reeling machines. More than 75% of raw silk produced is only on Charaka. Only reason is inferior quality cocoons and its low cost of construction. In recent years, the improved quality in cocoons allowed to conduct reeling on all the reeling machines like improved Multi end, semi-automatic reeling machines. In advanced countries like China and Japan automatic machines are very much in use because of superior quality cocoon production.

In silk reeling sector multi-end reeling machine is best suitable to start an enterprise. The machine is used for production of high quality International Grade raw silk from Bivoltine and Multi-voltine Cocoons. Standard specifications for choosing required capacity of machine is given below.

Standard Specifications:

Capacity	4 BASINS	6 BASINS	8 BASINS	10 BASINS	12 BASINS
Length	3.2 Mtr	4.49 Mtr	5.79 Mtr	7.08 Mtr	8.38 Mtr
Width	1.52 Mtr	1.52 Mtr	1.52 Mtr	1.52 Mtr	1.52 Mtr
Production /8Hrs	4.8 Kg	7.2 Kg	9.6 Kg	12 Kg	14.4 kg
Motor 3 Phase	1 HP	1 HP	1 HP	1 HP	1.5 HP

Requirements to start multi – end reeling enterprise:

- Sufficient building space depending on number of basins as per above specifications.
- Sufficient water facility and water should be soft, other wise softening plant is required to soften water.
- Hot air stifling facility to maintain cocoon stocks to have regular rearings.

- Boiler to produce steam required for entire unit.
- Skilled operators depending on the size and number of basins.
- Re – reeling, lacing, skiening and baling or packing facility depending on quantity of raw silk reeled.
- Considerable demand for raw silk for local weaving sector and good marketing facilities.

8.4. Establishment cost of Multi – end reeling machine 10 basins with 10 ends

S.No	Items/Particulars	Unit price Rs/-	Quantity	Total Cost Rs/- South zone
1	Multi-end reeling machinery (10 ends/basin, 10 basins.	4,90,000	1	4,99,800
2	Circular pressurized cooking m/c/vacuum permeation cooking equipment	1,28,800	1	1,30,088
3	Two pan cooking table	15,700	4	63,428
4	Small reel permeation chamber	82,400	1	83, 224
5	Re-reeling (10 window/5 ends/ window	2,13,600	1	2,15,736
6	Electrical hot air drier/50kg capacity	1,30,000	1	1,31,300
7	Cocoon sorting table	11,300	1	11,413
8	Boiler 100 kg capacity with water softner (100 kg steam output/hour	1,75,000	1	1,76,750
9	Generator (5KVA Capacity)	85,400	1	86,254
10	Epprovett/electronic balance of 600 gr capacity 0.01 sensitivity	11,300	Set	11,413
11	Total	**13,90,600**		**14,05,000**

Norms:

- Raw material: Mulberry multivoltine or bivoltine cocoons.
- End product: A / 2A grade raw silk.

- By-product: Silk waste and pupae.
- Production rate: 1 kg per basin per shift of 8 hours.
- Working period: 1 shift of 8 hours per day; 25 days per month; 300 days per annum.
- Raw material requirement: 75 kg per day; 22.5 MT per annum.
- Raw silk production: 10 kg per day; 3 MT per annum.
- Silk waste generation: 2.5 kg per day @ 250 g per kg raw silk; 750 kg per annum.
- Pupae generation: 60 kg per day @ 800 g per kg cocoons; 18 MT per annum.
- Manpower requirement: 20 skilled workers.

Estimate of working capital requirement for multi-end reeling units

#	Details	10 basin unit (100 ends)
1	No. of basins installed	10
2	No. of shift / day (8 hours / shift)	1
3	Production rate per basin / day kg	1.000
4	Production capacity / day @ 100% utilisation (kg)	10.000
5	Renditta	7.5
6	Raw material requirement (sorted cocoons) / day (kg)	75.000
7	Defective cocoons per kg of cocoons @ 5% (kg)	0.050
8	Raw material (including defective cocoons) / day (kg)	79.00
9	Silk waste generation per kg of silk (kg)	0.280
10	Power / kg of yarn (Rs.)	12.00
11	Fuel and water / kg of yarn (Rs.)	50.00
12	Consumables / kg of yarn (Rs.)	2.00
13	Packing expenses / kg of yarn (Rs.)	4.00
14	Skilled workers requirement (No.)	20

Details	Price /kg (Rs.)
Bivoltine cocoons	275
Raw silk (2A grade)	2,000
Silk waste	300
Defective cocoons	125
Wages per worker / day	250

II. Details of working capital*(Rs.)*

S.No	Details	Holding period	10 Basin/ unit 100 ends
1	Raw material	25	5,43,125
2	Wages	25	1,25,000
3	Power	25	3,000
4	Fuel and water	25	12,500
5	Consumables	25	500
6	Packaging materials	25	1,000
7	Work in process	3	65,175
8	Finished goods	3	60,000
9	Bills receivable	7	1,49,450
10	Total working capital		9,59,750

Remarks:

Cost of raw material reckoned on the total quantity of cocoons required (inclusive of defective cocoons). Finished goods are reckoned based on selling price of raw silk. Bills reckoned based on raw silk, silk waste and defective cocoons.

Training division of CSB:

The Training Division of CSB also conducts specific need-based & tailor-made training programmes on request from external agencies for the overall benefit & development of silk sector. These programs are very much useful to the new entrepreneurs of agriculture and industrial sectors of sericulture. Before going to start an enterprise of sericulture, one should acquire the complete knowledge and experience of that particular field.

The following are some important training programs conducted by CSB.

1. **Resource Development Programme (RDP)/Trainers Training Programme (TTP)** - Aims to refine quality of human resource of the industry and develop groups of resource persons as master trainers with all desired sericulture knowledge, skills and competencies for imparting next level training to farmers/ project beneficiaries and other industry stakeholders. Eligibility: Project implementing officials from States, NGOs & CSB (1-2 wks)

2. **Technology Demonstration/Up-gradation Programme (TUP/TDP)** - Demonstration of modern technology and recently developed techniques, processes and equipments pertaining to different activities of silk value chain for improved quality and quantity. Eligibility: All farmers/stakeholders associated with sericulture & silk industry (1-2 days)

3. **Bankers Sensitization Programme (BSP) –** for sensitizing the Bankers and updating their information/ knowledge about sericulture sector by providing inputs on latest cocoon and raw silk production technologies and introduction to various bankable Seri-Business options. Eligibility: Bankers & LDMs (3-5 days)

4. **Management Development Programme (MDP)** – These programmes are meant basically for enhancing technical/professional/motivational levels of generally in-house participants and DoS officers/officials for introducing new developments in the field of Sericulture, Science & technology and other functional areas. Eligibility: In-house & State Govt. Officials (1-2 wk)

Management and Developmental Programe (MDP)

II. TECHNOLOGY UP-GRADATION PROGRAMMES (TUP):

S.No.	Course	Duration	Course Details
1	Chawki rearing for farmers 	8 days	Chawki silkworm rearing, disinfection & hygiene, organization of commercial CRC, maintenance of chawki garden, pest & disease control
2	Late age silkworm rearing for farmers	10 days	Late age rearing - shoot rearing technology, disinfection & hygiene maintenance, pest and disease control, spinning and mounting technology etc.
3	Integrated Nutrient Management (INMZ)	6 days	Growing green manuring crops, microbial aided compost technology, Vermicomposting, Biofertilizers - Azotobacter, Azospirullum, VAM, Phosphate solublizing microorganisms / Bacteria (PSM / PSB), Neem based pesticides, Trichoderma based biofungicides.

S.No.	Course	Duration	Course Details
4	Integrated Pest and disease Management (IPM) 	6 days	Disinfection, selection of disinfectants, estimation, preparation, disinfection of rearing house, Silkworm diseases and their management hygiene, bed disinfectants, mulberry diseases and their management, mulberry pests tukra & leaf roller and their management Silkworm pests uzifly, IPM to control uzifly.

Integrated Skill Development Schemes (Source CSB)

S.No.	Course	Duration	Course Details
1	Commercial Chawki Rearing	15 days	Commercial Chawki silkworm rearing, disinfection & hygiene, organization of commercial CRC, maintenance of chawki garden, pest & disease control. Managerial inputs including HRD and preparation of project for financial assistance.
2	Trading in sericultural inputs, hiring equipment/ machinery & consultancy	15 days	Use of secatuer, pruning saw, shoot cutter, weed cutter, sprayer, deflossing, bed disinfectant equipment, temperature & humidity control machine etc. Demonstration of power tiller & tractor ploughing Managerial inputs including HRD and preparation of project for financial assistance.
3	Preparation of bio-formulations and recycling of seri-residues	15 days	Preparation of bio-formulations like Raksha, Nursery guard, Bionema, campomix, chetak used for the control of root diseases of mulberry. Composting and vermi-composting techniques for conversion of seri-waste into value added manure. Managerial inputs including HRD and preparation of project for financial assistance.
4	Production and popularization of bio-control agents	15 days	Types of silkworm & mulberry pest and factors responsible for pest outbreak, Insectary facilities and requirements for mass production of bio-control agents, economics of mass production, techniques of release of biocontrol agents and their colonization, Visit to mass production units. Managerial inputs including HRD and preparation of project for financial assistance
5	Cocoon handicrafts	10 days	 Selection of cut cocoons, Selection of dyes, Preparation of dye for coloring the cocoon, Cutting of cocoons. Preparation of different types of flowers, Arrangement of flowers in vases, Preparation of garlands Preparation of greeting cards, wall plates.

Managerial inputs including HRD and preparation of project for financial assistance

Agri-Clinics and Agri-Business Centres ACABC Sceme):

Ministry of Agriculture & Farmers Welfare, Govt of India is providing free residential training programme on Agri entrepreneurship development for two months, executed by National Institute of Agricultural Extension Management (MANAGE) Hyderabad and supported by NABARD at Andhrapradesh State Sericulture Reasearch and Development Institute(APSSRDI), Kirikere, Hindupur. The main aim of this programme is to increase the self-employment skills in all Agri- sectors including sericulture. After completion of training they also guide to obtain loan up to Rs 20 Lakh with subsidy of 44% for Women, SC/ST and 36% for other candidates to establish their own enterprise of Agri-clinic in respective field of training undergone.

(***For more information one can contact Dr.A.K.Goel Mob: 9502003728), Dr.C.Ramesha-9949414030, Dr.S.V.Sheshagiri-9676083834***)

Short Answer Type Questions

1.What is the importance of EDP ?

2.Mention different areas of sericulture for EDP.

3.Mention different training programs of CSB

Long Answer type Questions

1.Write detailed account on EDP in Kissan Nursery OR egg production.

2.Write a brief note on EDP in Chaki rearing OR Multi end reeling

3.Write in detail about the various training programs for EDP conducted by CSB.

Glossary

Sericulture: It refers to mass scale rearing of silk producing organism in order to obtain silk from them.

Vanya Silks: The silk obtained from wild silk worms which are thrive on nature grown plants.

Tasar Silk: A wild type silk spun by Antheraea species feeding on Terminalia or Quercus leaves.

Muga Silk: The golden yellow silk spun by *Antheraea assamenses* feeds on som and soalu leaves.

Polyphagous: Habit of feeding on various types of food plants is called polyphagous.

Primary food plants: The food plants of first choice and give a commercial yield is called Primary food plants.

Secondary food plants: The food plants which are utilized for survivality, doesn’t give commercial yield is called secondary food plants.

Tubercles : The prominent protrusions (or) out growths on thoracic and abdominal segments. These out growth are called "Tubercles" which acts as sensors.

Out-door rearing: Rearing of warms openly on trees naturally is called out door rearing.

Cleaning: It is a process of removing or eliminating dust and dirt.

Slacked lime: It is a very effective disinfectant which dries the bed and kills the pathogens.

Fumigation : It is a gaseous form of disinfection.

Disinfection: The extermination or destruction of disease causing germs is called disinfection

Prothetely: Intermediate form between larva and pupa of an insect.

Spiracles: It is an opening meant for respiration in insects.

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SERICULTURE

Paper - III

SILKWORM REARING TECHNOLOGY

INDEX

UNIT 1

Hatching and Brushing

Structure

Learning Objectives

After studying this chapter students will be able to

- Understand how to handle silkworm eggs, how to conduct incubation and black boxing of the eggs.
- Identify the embryonic changes during incubation.
- Distinguish the head pigmentation stage and Blue egg stages.
- Calculation of hatched, unhatched, unfertilized and dead
- egg percentages.

1.1 Introduction

Success of Sericulture as a cash crop depends on the vitality and disease freeness of the silkworm seed supplied to the farmers. The silkworms are fed on the leaves of their food plants which grow and spin a protective covering around them called cocoon before transforming into a resting stage called pupa from which the silk thread is drawn. The process of raising the cocoon crops through feeding and caring the silkworm is known as rearing. The success of rearing is calculated in terms of quality and quantity of cocoon harvested and its returns. Hence, it is important to understand the different aspects of silkworm rearing. The pre-requisite for silkworm rearing such as choosing a suitable silkworm breed, estimation of leaf availability in the garden, requirement of the appliances, disinfection of rearing house, and maintenance of hygiene, etc.,

Silkworm, *Bombyx mori* L. a sericigenous insect is being reared since time immemorial and is completely domesticated. Silkworm eggs are of two types i.e. hibernating and non-hibernating eggs. Further processing of the eggs depends upon whether they are of the diapausing or the non- diapausing type. There are different types of silkworm eggs which are classified based on the voltinism *i.e.* number of generations in a year *viz.*, Univoltines which complete life cycle once in a year, Bivoltines twice in a year under normal conditions. However, uni and bivoltine eggs can be artificially made to hatch as and when required. Artificial hatching methods involve either subjecting silkworm eggs to acid treatment or artificial wintering (cold storage). The eggs stored are taken out and subjected to incubation to achieve uniform hatching on a desired day. This can be achieved by exposing the eggs to certain range of environmental conditions. The incubation of eggs is one of the essential and important parameter in silkworm rearing.

The process of raising the cocoon crops through feeding and caring the silkworm is known as ‘rearing’. The mulberry and eri silkworms are reared indoor while other silkworm such as Tasar and Muga are reared outdoor on their respective food plants. In general all varieties of silkworms pass through the stages of egg, larva, and pupa enclosed within a protective cover called cocoon and adult (moths). The adult female moth mate with male moth and lay eggs to continue their generation.

Silkworm rearing requires care and skill, since various rearing operations are important which finally reflect on the cocoon quality and yield. The rearing activity starts with brushing of newly hatched silkworms. Silkworms are susceptible to various kinds of diseases and cannot withstand to the environmental fluctuations. The rearing room should be prepared in such a way not to hamper the growth of the silkworms.

The equipment such as foam rubber strips, chawki rearing trays, feather, paraffin paper, chopping board and knife, mats have to be kept ready for rearing. The desired race of silkworm DFLs (Disease Free Layings) are procured from Grainage. The eggs are protected from ants, rats. They are properly incubated and later kept in black box at blue egg stage. The process of brushing and the methods involved are explained in this unit.

1.2 Incubation

The development of the embryo inside the egg starts from the time of its fertilization and these have to be taken care from that time itself including the periods of transport. The eggs need to be well aerated and prevented from desiccation. Around 25^{o}C temperature and a relative humidity of about 80% and 16 hours light alternating with 8 hours darkness is ideal. To provide sufficient aeration, it is suggested to carry them in containers or packets with holes on it and loosely packed. To protect them from high temperature, it is advised to carry them either in the cooler hours of the day, early morning or evening hours. To eliminate possible surface contamination, the eggs are to be surface sterilized with 2% formalin. The modern way of incubating the eggs is to spread them in trays in the incubator having facilities to control temperature, humidity and light hours.

Incubation is the process of facilitating the growth and development of the embryo inside the egg till hatching. It involves providing the required ambience to the egg which includes the required temperature, relative humidity, light and aeration. Usually the farmers place, the egg sheets or loose eggs spread in the rearing tray on a paraffin paper, cover them with another tray and then with moist cloth. In summer, when the temperature is much higher, the eggs are incubated in earthen pots which are kept in wet sand and covered with wet cloth. In dry climate, a mud pot would be able to reduce the temperature.

The environment influences the stored eggs in the development of the embryo, uniform hatching of the worms, health of the larvae, mortality and yield of cocoons. Thus the silk worm eggs are kept under proper incubation process to get high and uniform rate of hatching on the desired date, good larval health and high cocoon quality. Ideal incubation process is a key keen factor for achieving good quality cocoon crop.

The incubation room, chamber must be clean. Room heaters and cooling arrangements must be prefect so as to maintain uniform temperature and humidity throughout the incubation process. The egg cards are arranged in such a way to expose all the eggs to the ambient temperature and room humidity. High temperature though makes the eggs hatch earlier, results in a large proportion of the eggs dying or becoming weak and sometimes they do not hatch at all and very irregular hatching is observed. Humidity also plays vital role in incubation, lack of optimum humidity result in poor hatching. High humidity makes the worms easily susceptible to diseases.

Light intensity during incubation speeds up embryo growth and hatching. It is possible to stimulate and synchronize the hatching dates of all the eggs. Silkworm eggs may be kept under a photoperiod of 16 hours daily until 30 - 40% of the eggs reach blue egg stage. At this stage eggs are kept in dark/black boxes for more uniform hatching.

Incubation room should be properly ventilated or aerated and good ventilation provides good circulation of air which drives away the poisonous gases produced due to metabolic activity of silkworm eggs and active developmental process. Chawki Rearing Centers which incubate the eggs in large quantities can have a small room with regulated temperature, humidity, light, ventilation etc.

If any unexpected reason, for which the hatching has to be delayed after incubation has started, can be done to a limited extent by cold storing the eggs at 5^0C on the second or third day of incubation for about a week. Hatching can be delayed at blue egg stage by cold storing eggs for 3 - 5 days at 5^0C. Brushing can also be delayed by cold storing the newly hatched larvae for about three days at 5 – 7^0C. It is advised not to postpone the hatching unless there is urgency.

1.2 Handling of Eggs

The incubated eggs are handled properly to get good hatching percentage, otherwise harmful effects may result in poor hatching. Silkworm eggs are produced in central places, *viz.*, by the Government grainages or private licensed seed producers. Rearers have to purchase the eggs from egg producing centers only. Hence, there is a need to transport eggs properly to ensure healthy and uniform development of the eggs.

Live silkworm eggs are transported (Fig. 1.1) from egg producing centers (grainages) to the rearer's rearing places or chawki rearing centers (young silkworm rearing centers) with proper care even during transportation, it is important to maintain optimum temperature and humidity.

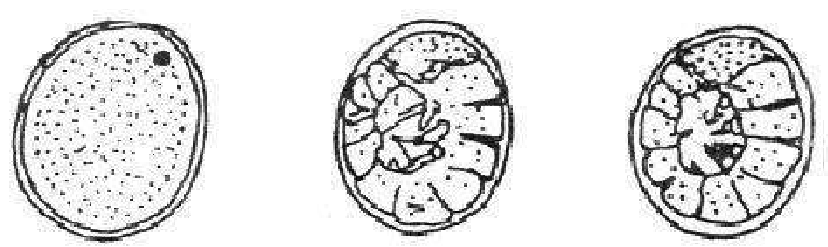
Fig. 1.1. Egg transportation device

The silkworm eggs are live material and should be handled properly to avoid damage to the developing embryo. The embryos need oxygen which should be made available by proper circulation of air in the container used for transportation. Non-supply of air results in suffocation which affects the healthy development of the embryo. The developing embryo needs optimum temperature and humidity. If the temperature is more than the optimum, it affects the development and physiological activity of the embryo.

Eggs exposed to high temperature (above 28^0 C) and humidity (over 90%) during egg-laying and incubation; storage of hibernating eggs at 25^0 C for too long period or under dry and high temperature conditions; stimulation of eggs in acid treatment; contamination of eggs by pesticides, glue or gum causes rottening of eggs before the onset of the head pigmentation. Rotten eggs are dead eggs which perish after the colouring of the serosa and before head pigmentation with sunken shell and deep cavity. Too high temperature (over 28^0 C) during incubation, too low relative humidity (less than 50%), contact with pesticides or other harmful chemicals causes dead eggs after head pigmentation. In such type of eggs, the embryo is normally formed in the egg shell but death occurs before hatching stage. Keeping this in view, the eggs are to be handled carefully till hatching so as to ensure uniform and more hatching.

1.3 Black boxing

When the eggs are incubated under suitable conditions reach to pin head or head pigmentation stage in 7-8 days (48 hours before hatching) (Fig. 1.2 and 1.3). This first pigmentation can be seen through the egg shell as a blue spot and this stage is called “eye spot or pin head” stage. On the following day the whole embryo turns black due to the development of body pigments and appears bluish-black through the egg shell and called as “blue egg stage”.



Egg structure

Fig. 1.2. *Bombyx mori* eggs during embryo development

Fig. 1.3 *Bombyx mori* eggs during blue egg stage

Fig. 1.4. Black Boxing of silkworm eggs

Light has profound effect on silkworm egg hatching. Providing total darkness for a day or two days before egg hatching is called 'Block boxing' (Fig. 1.4). This helps in uniform hatching in a single day. During black boxing, those embryos in advanced stage of development will wait for light to hatch and the developing embryos will continue their development and when exposed to light, all eggs will hatch uniformly.

By around 8th or 9th day from the day of laying, the embryo becomes sensitive to light with accelerated growth. This stage is called pinhead stage. At this stage, the eggs are kept under total darkness either by wrapping them with black paper or keeping them in a black box or dark room for the next two days. The process is called black boxing. Thus, we can bring about synchronization in hatching all eggs together on the same day. There are different methods like black paper method, black cloth method and wooden box method. The duration of black boxing ranges from 48 to 72 hours after the pigmentation stage. The eggs hatch out in response to phototropic stimulus. This method favours hatching more than 90 per cent. In this way early maturing embryos are prevented from hatching and late maturing embryos are given time to develop and catch up with the early maturing ones.

1.5. Hatching

If hatching is not uniform and only 50 - 60 percent of eggs are hatched on the first day, brushing can be postponed to next day as well. If necessary, hatched worms can be separated and kept in tissue paper and stored in refrigerator. The next day along with the refrigerated worms can be brushed together. The eggs hatch around 10^{th} day of after egg laying or two days after the pin head stage (Fig.1.5). At this point of time, a number of larvae would have already hatched. The eggs are brought out of the black box or dark cover and exposed to diffuse light of the day in the early morning. If required, they are placed under the lamp taking care that the eggs are not heated up. This activates the process of hatching and in about 2-3 hours, almost all the eggs hatch out. Over 95% hatching is considered as good hatching.

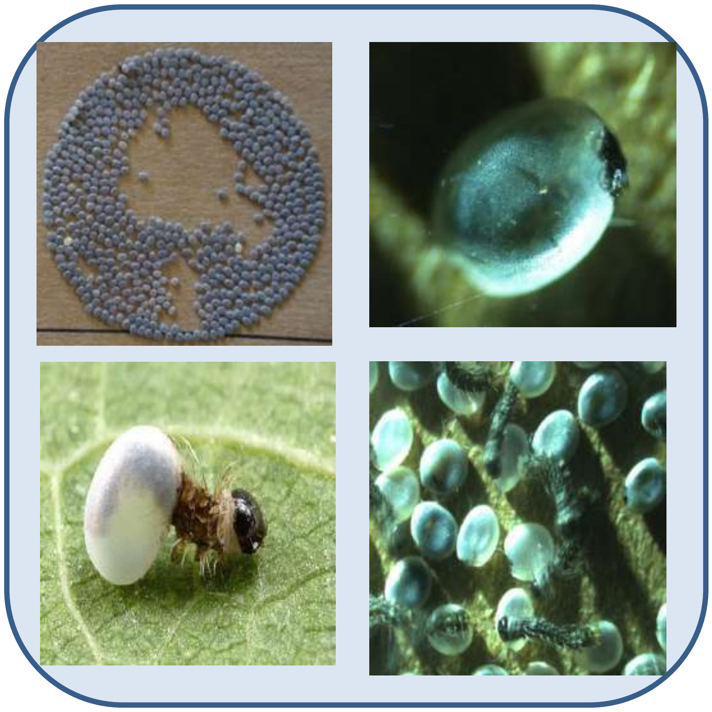


Fig. 1.5. Hatching of silkworm larvae

Silkworm eggs are available loosely or on egg cards. The newly developed larvae break out the egg shell and come out and the process is called hatching. The hatched larvae are brushed and reared. The newly hatched larvae are black, hairy and look like small ants and are called “ants” or “kego”. It is always better to brush the larvae in the morning. The eggs exposed in early hours or hot hours results in irregular hatching. Generally brushing should not be delayed. If necessary, can be postponed to next day when hatching is irregular. Brushing should be completed in the morning/cool hours of the day. Freshly emerged larvae can also be preserved at 7-10°C for one day.

1.6. Hatching Percentage

The ratio between hatched eggs and total number of eggs in a laying is called “hatching percentage”. The hatched eggs, unfertilized or dead egg number is counted individually for calculating the percentage.

This can be done using a different coloured sketch pens usually red and later it is calculated using the following formulae.

After brushing of silkworm larvae, in a silkworm egg laying consists hatched eggs (empty shells), embryo developed but not hatched, dead eggs (Eggs with rotten embryo) and unfertilized eggs (only yolk is seen). Hatched eggs indicate the proper development of embryo right from fertilization to hatching of larvae. Unhatched egg indicates improper development of embryo and may be due to lapses during incubation and improper block boxing. Dead eggs may be due to genetical character and improper handling of silkworm eggs during egg production. Unfertilized eggs indicate the weak potency of male moth, less copulation period and high temperature during egg production process.

Hatching percentage for total eggs

$$= \frac{\text{Total number of hatched eggs}}{\text{Total number of eggs}} \times 100$$

Usually it is calculated to know the overall hatching out of all the eggs given.

Hatching percentage for fertilized eggs

$$= \frac{\text{Total number of hatched eggs}}{(\text{Total number of eggs} - \text{Number of unfertilized eggs})} \times 100$$

Usually it is calculated to know the embryonic development and hatching out of fertilized eggs alone.

$$\text{Unfertilized egg percentage} = \frac{\text{Total number of unfertilized eggs}}{\text{Total number of eggs}} \times 100$$

Number of total eggs =

Number of hatched eggs+ Number of un hatched eggs + Number of unfertilized eggs + Number of dead eggs

Model Problem

In a laying, Total number of eggs are 445, out of which 415 hatched. Find out the hatching and unhatched egg percentage.

Total number of eggs = 445

Number of hatched eggs = 415

Un hatched eggs = Total number of eggs - hatched eggs

= 445 - 415 = 30

Unhatched eggs = 30

$$\text{Hatching percentage} = \frac{415}{445} \times 100 = 93.26\%$$

$$\text{Un hatched egg percentage} = \frac{30}{445} \times 100 = 6.74\%$$

Example -1

In an egg laying, total eggs are 475 out of which 20 eggs did not hatch which includes unfertilized eggs of 5. Find out hatching percentage to the total eggs and to fertilized eggs and unhatched percentage.

Total eggs = 475

unhatched eggs = 20

unfertilized eggs = 5

Hatched eggs = Total eggs – unhatched eggs

= 475 – 20 = 455

Hatched eggs

$$\text{Hatching \% for the total eggs} = \frac{}{\text{Total eggs}} \times 100$$

$$\text{Hatching \% for the fertilized eggs} = \frac{\text{Hatched eggs}}{(\text{Total eggs} - \text{unfertilized eggs})} \times 100$$

Hatching percentage for total eggs

$$= \frac{455}{475} \times 100 = 95.78\%$$

Hatching percentage for fertilized eggs

$$= \frac{455}{(475 - 5)} \times 100 = 96.80\ \%$$

1.7. Brushing of larvae

The process which involves the transfer of newly born larvae to the rearing tray or rearing bed is called 'brushing'. In 4' x 3' tray, 50 Dfls can be brushed and reared upto first moult and 25 Dfls upto 2nd moult. When the eggs hatch, the emerged larvae are to be collected for rearing. This process of separating kego / ants from egg sheet or egg shell is called "brushing". It involves sprinkling of thinly chopped mulberry leaves on just hatched larvae to attract them to feed. The larvae which crawl on to leaves will be separated and transferred to rearing tray from their shells by using feathers. Optimum time for brushing is around 10 am of the day.

Normally hatching starts at 5 – 6 am when the eggs are exposed to diffused light. Uniform hatching can be expected by 7-8 am. After 2 hours, the newly hatched worms develop appetite and begin to crawl. Thus the suitable time for brushing would be 10 am but once again it depends upon the weather conditions. Before brushing, rearing facilities should be prepared according to the number of layings (Dfls) to be reared.

1.8. Methods of Brushing

Brushing of eggs is of two types depending on type of eggs.

1. Brushing of loose eggs.
2. Brushing of sheet eggs.

1.8.1 Brushing loose eggs

The eggs are spread evenly in one layer in the egg box and kept in black box at blue egg stage. On the next day, when all eggs reach blue egg stage they are removed from black box and covered with a thin perforated cloth or a fine mesh or finely perforated paper (Fig.1.6). This covering is placed in such a way that it just touches the upper surface of the eggs. Then just before brushing, chopped mulberry leaves are sprinkled on the top of the net or cloth or paper. This mulberry leaf attracts the hatched worms to crawl on to the upper surface. When maximum number of worms hatches out and crawls on to the paper they are transferred to rearing tray.

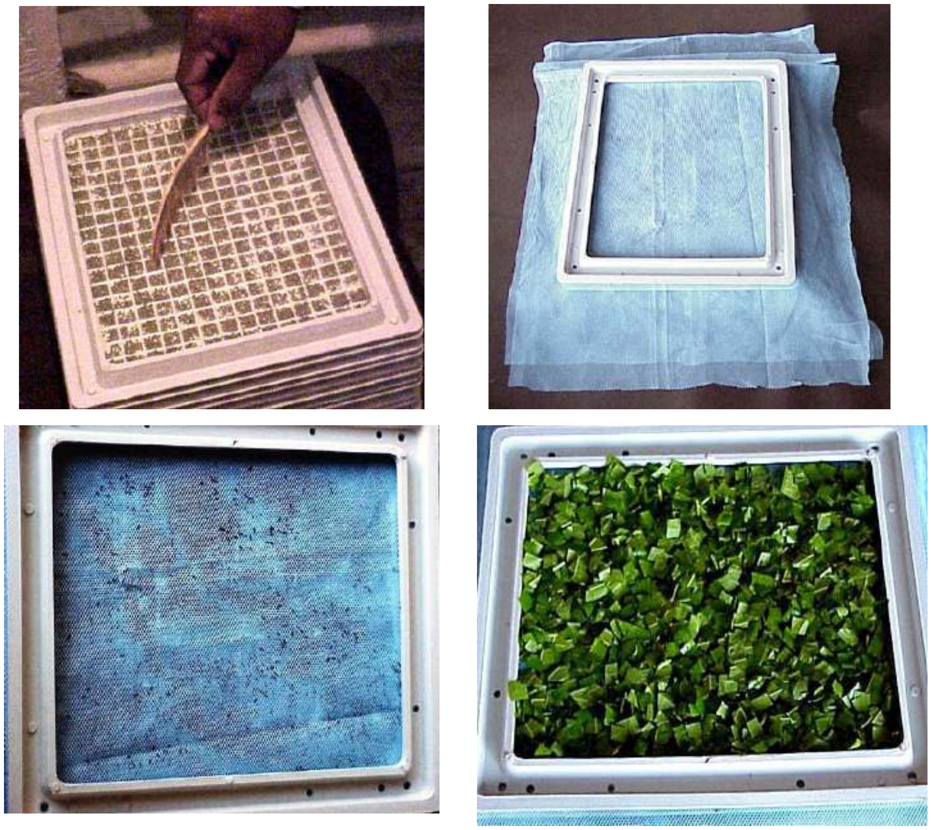


Fig. 1.6. Brushing of Loose Eggs

Advantage of loose eggs

- Superior quality
- Uniform and known quantity irrespective of race / season / zone / grainage etc.,
- Enables scientific evaluation
- Increased egg recovery
- Increased hatchability
- Economical seed production
- Efficient surface sterilization
- Easy acid treatment of bivoltine eggs.
- Unfertilized eggs can be eliminated

1.8.2 Brushing egg cards

The transfer of the newly hatched larva from sheet eggs (Fig.1.7 & Fig.1.8) to rearing tray in various methods. Generally the farmers sprinkle chopped mulberry leaf on the sheet eggs and transfer these worms to rearing tray by using feather and the brushing of sheet egg procedure is discussed.

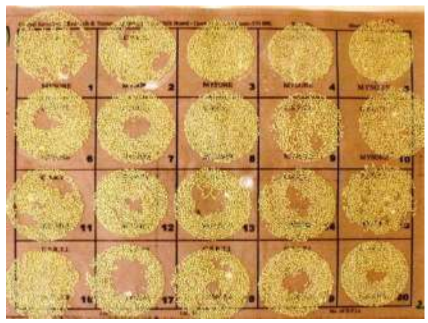


Fig. 1.7. Silkworm egg sheet

Fig.1.8. Hatching of larvae on sheet eggs (Multivoltine & Bivoltine)

Generally the sheet eggs are brushed by the following methods and the details of which are as follows.

(a) Tapping method

The hatched larvae which crawl towards the edges or corners of the egg sheet are collected in to rearing tray using a feather. The egg sheet is held upside down just above the rearing tray and tapped. The larvae fall on to the rearing tray arranged with paraffin paper and the dropped larvae are brushed together with feather and fed with chopped mulberry leaf.

(b) Feather method

The hatched larvae which crawl towards the edge or corners of the sheet are collected gently with white feather. Hold the egg sheet slantwise to the rearing seat, transfer larvae with the help of a feather. (Fig.1.9). Later worms are fed with finely chopped mulberry leaf.

Fig. 1.9. Brushing by Feather

(c) Brushing with mulberry leaves

Mulberry leaves chopped to 0.5 sq.cm size are sprinkled on the egg sheets when larvae hatch out. The mulberry leaf attracts the larvae. After 10 minutes the egg sheet is turned upside down and larvae along with mulberry leaf are transferred to rearing tray using feather.

(d) Husk - feeding method

Finely powdered paddy husk is sprinkled, evenly over the eggs sheet when the larvae hatched. Then finely chopped mulberry leaves are sprinkled over the worms which crawl on to leaf are transferred to rearing tray by using feather.

(e) Net and feeding method of Brushing

In this method, a net is placed on the hatched larvae and the chopped leaves are sprinkled over the net. The leaves attract the larvae.

After 30 minutes of time, leaves and net along with worms are transferred to another rearing tray.

1.9. Leaf harvesting methods, transportation and preservation

The nutritive value of the leaf changes according to the photosynthetic and respiratory activities of the leaf. Leaves harvested late in the afternoon contain less water and more of carbohydrates due to the active photosynthesis and transpiration taking place in day time. Such leaves wither more quickly and hence it is recommended to harvest leaves in early hours of the morning.

The method of harvesting leaves varies in different areas according to the rearing method used and also may be to some extent modified to suit the extent of rearing and availability of labour at the given time. Three methods of leaf harvesting are quite common in sericulture.

Leaf Picking: Leaves are harvested (Fig.1.10) individually from the main stem with petioles and at the same, the terminal buds are pinched off so that the lateral shoots develop rapidly and sufficient leaves are available for the next crop. Leaf picking can be done at an interval of 7 - 8 weeks. The main advantage of this method is that leaves can be selected to suit the growth stage of the larvae, young leaves for the infant stages and mature leaves for grown up stages. The main disadvantages are that it requires more labour and further the leaves wither too quickly.

Fig. 1.10. Harvesting of mulberry leaf

Branch cutting: This method called ‘Batchi’ system, this method is practiced in Kashmir and also in West Bengal and parts of Karnataka in India. In this method the entire branch is harvested and used to feed worms directly after the third moult. This method saves labour in harvesting of leaf and also in feeding, spacing and bed cleaning operations. Leaves of entire branches retain succulence for a longer period. The hygienic condition of rearing house is easier to maintain.

Whole shoot harvesting: This method of harvest consists of cutting the branches to ground level by bottom pruning and feeding the entire shoot to larvae after fourth moult. Shoots are harvested at an interval of 8 – 10 weeks and thus 5 - 6 harvests are made in a year. As shoots are cut to ground level, the shoots sprouting reach uniform maturity by the next harvest and this method is possible only in areas where sprouting is possible throughout the year.

Transportation and preservation of leaves: Like any other animals, silkworm also prefer fresh mulberry leaves for feeding and to ensure quality feed, it is necessary to plan properly the harvest and transport of leaves. Care should be taken to collect leaves as per requirement and transported in shortest period (Fig.1.11). Leaves should be transported in bamboo baskets covered with gunny cloth and shoots in bundles.

Mulberry leaf has to be transported during cooler hours, if they are to be transported for longer than 30 minutes by tractor or head load, they should be covered with wet gunny cloth to reduce moisture loss.

Fresh mulberry leaves contain a lot of starch which is not palatable to silkworms. They are also not highly nutritious. Generally two harvests are done per day and the silkworms are fed with fresh leaves. During the period from harvesting to feeding mulberry leaves are preserved and stored. During the period of storage due to metabolic activities of the leaves, its chemical constitution is altered. The most visible change is the withering of leaves by water loss. There is a net loss of water which is proportional to the time of storage. In the initial period of storage starch is broken up to sugars, the increase of which leads to a higher nutritive value and palatability of the leaves to the worms. During the period of storage, the proteins are broken to amino acids and there is no net decrease in total nitrogen. The crude ash and fiber content are not affected. The major changes during storage of leaves are water loss and deterioration of nutritive value by the breakdown of carbohydrates and proteins.

Leaves / shoots harvested should be preserved in a clean and disinfected room where high humidity and low temperature are maintained. Mulberry leaves for chawki worms may be stored in bamboo baskets and for late age worms require storage in larger wooden or bamboo leaf chambers covered on all sides with wet gunny cloth. Both the leaves and shoots should be preserved loosely and periodic turning of leaves is suggested to check the fermentation and to expel the respiratory heat. Mulberry shoots should be preserved in vertical position and covered with wet gunny cloth to prevent moisture loss.

The leaves are to be stored by spreading them in thin layers and covering them with wet gunny cloth and the maximum period of storage should not exceed 24 hours to ensure quality feed to silkworms.

Summary

- *The ultimate purpose of incubation of silkworm eggs is to secure uniform growth and development of embryo.*

- *During the incubation process, optimum environmental conditions such as 25^{0}C temperature and 80% humidity are to be maintained.*

- *Incubation room / chamber must be clean and should possess required chemicals, disinfectants, equipments.*

- *Non-hibernating eggs and eggs after acid treatment require 80-85% humidity and 24-25^{0}C temperature right from the beginning.*

- *Eggs at Blue egg stage are to be kept in dark/black boxes for uniform hatching.*

- *The eggs before (48 hours) hatching reach head pigmentation or pin head stage and is called eye spot stage. On the following day embryo turns black and called as blue egg stage.*

- *Black boxing is a process keeping blue egg stage eggs in black boxes to ensure uniform hatching of about 90-95% of silkworm larvae at a time.*

- *Newly hatched larva is called ant or kego.*

- *Brushing is the process / activity, wherein the separation of newly hatched worms from the egg shells taken place.*
- *While brushing loose eggs, perforated thin cloth is spread and later chopped mulberry leaf is sprinkled over the cloth, then the worms are transferred by feather in to a clean tray.*
- *While brushing, care must be taken not to damage the silkworms.*

Short Answer Type Questions

1. Purpose of incubation of silkworm eggs.
2. Define blue egg stage.
3. Define purpose of black boxing.
4. Define ‘kego’ or ‘ant’.
5. Required temperature and humidity during silkworm egg incubation.
6. Formulae for calculation of hatching percentage.
7. Define Brushing of silkworm eggs.
8. List out methods of brushing.
9. Define is a DFL.
10. List out methods of leaf harvesting.

Long Answer Type Questions

1. Importance of incubation and procedure involved during incubation process of silkworm eggs.
2. Care to be taken during handling of silkworm eggs and its importance?
3. Write about black boxing of silkworm eggs and its advantages?
4. Write in detail about leaf harvesting methods.
5. Write short notes on

   (a). Hatching. (b). Blue egg stage. (c). Brushing.
6. Calculate hatching percentage using these values

   Total eggs = 530, Hatched eggs = 512, Dead eggs = 10,
   Unfertilized eggs = 15
7. Detail the process of brushing of loose eggs.
8. Describe methods of brushing from egg card.
9. Write shot notes on

   (a). Hatching (b). Blue egg stage (c). Feather method.

UNIT 2
Chawki Rearing

Structure

Learning Objectives

After studying this unit, students will be able to

- Understand chawki rearing methods
- Identify the moulting and out of moulting worms
- Understand the importance of chawki rearing centers
- Know importance of quality feeding and spacing schedules

2.1. Introduction

The life cycle of silkworm consists of egg, larva, pupa (cocoon) and adult stages. Among these four stages, larval stage is the feeding and active stage. The young silkworms usually up to the end of second instar are called chawki worms. Rearing of young age silkworms up to 2nd moult is called as chawki rearing. This stage of larvae requires ideal environmental conditions and tender mulberry leaves. Robust growth and development of chawki larvae make them resistant to diseases and more stress tolerant during later stages of development.

The Chawki worms are tiny and delicate; the chances of damage are much brighter during handling. They also require highly nutritive and easily digestible food. At this stage, they require a slightly higher temperature (around 28°C) and relative humidity (around 80%) than their later stages. Chawki rearing involves providing the young silkworms with succulent leaves, maintaining their freshness by preserving the leaf moisture content, providing its required environment during feeding and moulting and sanitation. Young silkworms are to be reared in scientific manner to ensure crop success and harvesting higher cocoon yield.

Concept of chawki rearing: To raise a healthy stock of silkworms the system of chawki rearing must be quite effective in the following:

- Maintenance of optimum temperature / relative humidity.
- Maintenance of absolute hygienic conditions.
- Feeding of nutritious tender leaves.
- Rearing of chawki worms by an experienced chawki rearer.

2.2. Quality of mulberry leaf

The mulberry leaf is the exclusive food of the silkworm *Bombyx mori* (L). The growth of the silkworm depends on the quality of leaves fed to them. The leaf quality is influenced by various factors such as soil, pruning, fertilizers, rainfall, irrigation etc., with these conditions mulberry grows luxuriously with rich contents of proteins and carbohydrates and the leaves are succulent due to high nutrient content. These types of leaves are edible for silkworms for better growth and to produce quality cocoons. The leaves of mulberry grown on loamy soil contain more water, protein, less carbohydrates and fiber.

Mulberry grown in sandy or gravel soil mature quickly becoming rough and coarse. These leaves contain less moisture, protein and more carbohydrates and fiber. Application of balanced fertilizers with major elements required by the plants improves both physical and chemical properties of the leaves. In well distributed rainfall or irrigated conditions, the mulberry growth is vigorous. Leaves of these plants are rich in nutritive value and are soft and succulent. With reference to the quality of mulberry leaf, the requirement of young silkworms is completely different from those of late age worms. The chawki worms require tender, soft and succulent leaf having higher contents of moisture, protein, sugars and less starch and fibre.

The quality of leaf may vary considerably from season to season. In summer the leaves grow and mature fast, but wither quickly. In rainy season, the leaves grow and mature fast and contain more moisture. Because of high moisture content, humidity increases in the rearing beds. Therefore, it is necessary to keep down the humidity of the bed under control through feeding of required quantity of leaf.

2.3. Leaf Selection

Mulberry leaf for young silkworms has a great effect on the growth and health of silkworm. Therefore selection of leaves should be done carefully. The leaves for young silkworms must be soft, tender, rich in water content, protein, carbohydrates etc. For Chawki rearing, S36 variety maintained under irrigated conditions is ideal. As the worms grow, medium leaf should be used for feeding the worms. There is high correlation between moisture content in the top tender leaves and chawki worm growth and moulting. Therefore for harvesting the correct leaves for young worms, the largest leaf method is adopted.

2.3.1. Glossy leaf method

To identify the glossy leaf, hold the upper part of shoot lightly and move the hand upward gently. Then appears a large leaf which stands out at the top (**Fig.2.1**). This is identified as largest glossy leaf. Otherwise holding the upper part of the shootlet lightly between fingers and bend it horizontally. Then a leaf stands up right is identified as largest glossy leaf. Now the first instar are fed with 4^{th} and 5^{th} leaves downward from the base of glossy leaf, for second instar 5th-7th leaves, for third instar 7-8 leaves to downward are harvested.

2.3.2 Lenticel and Bud (LB) Method

In this method the colour of the lenticel and auxiliary buds are used to harvest good leaves corresponding to the stage of worms. The colour of auxiliary buds changes from top to bottom of the branch. From top to bottom is green, apical buds are brownish, striped, non-accomplished and accomplished buds. The leaf with yellowish lenticel at the base of leaf petiole found above the apical brownish buds is used for first instar.

Leaves from the brownish lenticel through the apical brownish lenticel through the non-accomplished bud are used for third instar.

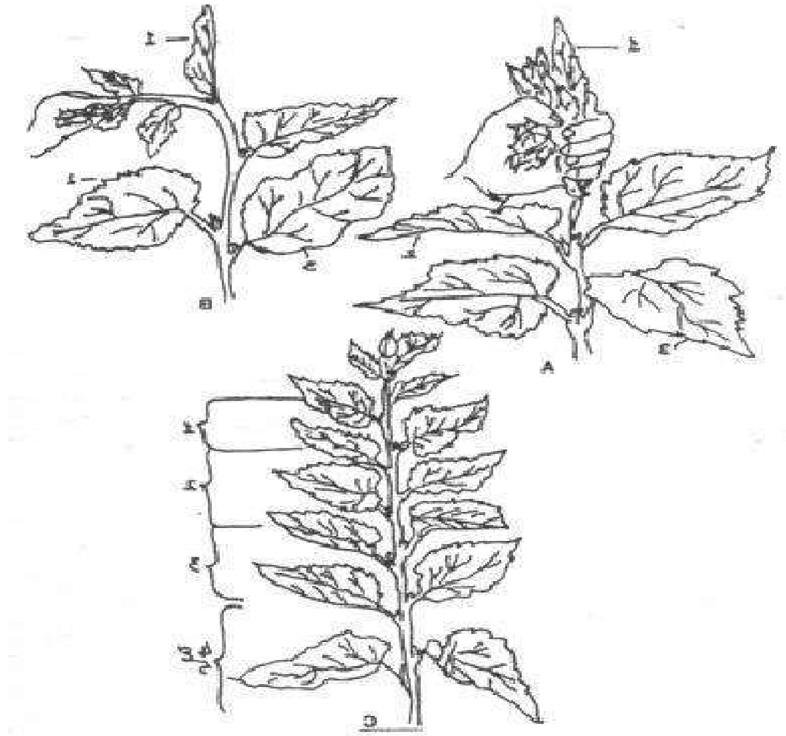


Fig. 2.1. Glossy leaf selection

2.4. Feeding Schedule

Silkworms are to be fed by ensuring the supply of quality mulberry leaf of required quantity and at various feeding timings.

2.4.1. Feeding

Feeding must satisfy both the appetite of the larva and its nutritional requirements. The first deals with the amount and frequency of feeding for each instar and the second with the quality of leaves. Silkworms are fed to satisfy their appetite. Thereby uniform and healthy growth of silkworms can be achieved. For this, quality leaves are to be preserved and rearing beds are kept clean. Feeding with excess leaves is not economical.

The main objectives of feeding are

1. To satisfy the appetite of larvae.
2. To promote eating and digestion of leaves by larvae.
3. To keep the quality of leaves during eating.
4. To keep rearing beds clean.
5. To avoid wastage of leaves and labour.

Fig 2.2. Mulberry leaf for chawki silkworms

Generally early age silkworms eat leaves from the surface, while late age worms from the edge. The feeding activity of each instar of silkworm can be conveniently divided into seven stages.

1. First feeding stage
2. Sparse eating stage
3. Moderate eating stage
4. Active eating stage
5. Pre moulting stage
6. Last feeding stage
7. Moulting stage.

The tiny worms which feed on the surface of the leaves should be able to reach the surface of leaf easier and speedier. To facilitate this provide them chopped leaves of about 1cm^2 size (Fig. 2.2). Chopping of leaves also helps in loosening and spreading of the bed.

2.4.2 Growth of Silkworms

Silkworms show high rate of growth (Fig.2.3. & 2.4). The growth by weight, between hatching and final spinning of cocoons stage is 10,000 times which is achieved in 24 to 25 days based on environmental conditions. For achieving full growth of silkworm scientific methods of rearing are followed by which worm grows to a weight of 4 - 5 gr. These worms are healthy and produce cocoons of 1.75 - 2.0 gr. and above in weight. The growth of the worms mainly depends upon the amount of mulberry ingested and digested (Table 2.1). The growth rate of silkworm varies with meteorological conditions. When the temperature is high the silkworms grows fast, but low temperature slows down the growth rate. The weight of worms increases 15 times from hatching to the end of I age, 4 - 5 times at I age, 5 times at III age, 5 times at IV age and 5 times at V age (Table 2.2). Thus the weight of full grown larvae will be from 8,000 - 10,000 times that of newly hatched larvae which is about 0.0003 to 0.0005 gm. The quantity of leaf required for rearing 50 layings up to III instar are given in Table 2.3.

Table 2.1. Amount of mulberry ingested and digested by silkworms.
(per 1000 larvae in green weight)

Stage	Amount of leaves ingested (gr)	Amount of leaves digested (gr)	% of Ingestion	% of the total amount ingested (g)	Amount of leaves digested (gr)	% of Digestion
I	60	14	24.08	0.06	7.7	53.4
II	223	89	39.7	0.37	45	51.0
III	970	480	49.5	1.86	192	40.0
IV	5333	2420	45.4	10.16	961	39.7
V	35150	19610	55.7	87.55	7655	39.1

Source: *Synthetic Sericulture*

Table 2.2. Silkworms body weight and size, during different instars.

When weighed	Increase in weight (No. of times)	Increase in size (size of newly brushed worms)
Immediately after hatching	1	--
2nd instar after moult	10 - 15	10 – 12 times
3rd instar after moult	75 - 100	50 – 80 times
4th instar after moult	350 - 500	300 – 400 times
5th instar after moult	1800 - 2200	1500 – 1800 times
At maximum of growth	8000 - 10000	8800 – 9000 times

Table. 2.3. Leaf requirement for 100 Dfls

Stage of the worms	Quantity of leaf to be fed	
	Multi x Bivoltine (Kg)	Bi x Bivoltine (kg)
I	5	6
II	13	17
III	60	80

Fig. 2.3. First instar silkworms **Fig. 2.4**. Second instar silkworms

2.4.3. Preparation of leaves for feeding young worms

Depending on the size of the worms, complete leaves can't be used for chawki worms. Further the leaf quality also influences the process of chopping. The quantity of leaf to be fed each time should not be more to avoid wastage of leaf. However the cut surfaces of leaf leads to loss of moisture. Therefore it is essential to adjust the chopping of leaf so as to protect the quality of leaf. The withering of leaf in rearing bed can be prevented using paraffin paper and foam rubber or paper soaked in water. This induces to raise humidity in the rearing beds.

Fig. 2.6 Leaf Chopping **Fig. 2.7** Feeding Chawki worms

The main advantage of chopped leaf is to facilitate even distribution of feed to the worms. In cold conditions chopped leaves prevent the silkworm bed from dampness. Leaves do not curl up when the air is not dry. However a greater amount of leaves are wasted beside labour expenses.

Depending on the shape of the chopped leaves (Fig.2.6) there are three methods of chopping. They are square, oblong and triangular. The square method is best of all which prevent leaf drying due to the drying proceeds from edge to center is prolonged. Long thin strips of oblong shapes are suitable when the season is wet. Chopping of leaves must be regulated and fed (Fig. 2.7) according to the condition and size of the worms. Thus the surface of the chopped leaf is equal to the square of the length of the worms. The size of the chopped leaf for chawki worms is given below (Table 2.4.).

Table 2.4. Leaf size requirement at various stages

Instar	Leaf size (cm2)		
	To start with	**Peak eating stage**	**Preparation for moult**
I	0.5	2.0	1.0
II	2.0	4.0	1.5
III	4.0	Full leaf cut in to four Pieces	2.0

Chopping of leaves (Fig. 2.8) is carried using chopping board and knife. Leaf is arranged in regular layers and cut to the required size depending on the age of the worm. All the chopped leaves are collected in a clean mat and loosened. Then the chopped leaves are sprinkled in the rearing tray. While cutting the leaves care has to be taken not to crush or bruise the leaves.

Fig. 2.8 Chopping of mulberry leaf

2.4.4 Frequency of Feeding

The frequency of feeding for chawki worms depends on the season. Care should be taken to feed the silkworms a sufficient quantity of leaves. An insufficient supply of leaves results in irregular growth and irregularity at moult. Hybrid silkworms have higher appetite than pure races and so consume more leaves.

Generally, chawki worms are to be fed 3 – 4 times a day with succulent and freshly chopped leaves. This varies from time to time and from place to place. In earlier days during summer, six feedings per day (7:00 am, 11:00 am, 2:00 pm. 5:00 pm., 8:00 pm and 11:00 pm) were given and in other seasons five feedings (6:00 am, 10:00 am, 2:00 pm, 6:00 pm and 10:00 pm) were given. Due to technological upgradation and better management practices, at present the farmers are providing 2 – 3 feedings per day. The amount of leaves given per feeding is adjusted to suit the appetite of the worms. This can be judged after a little practice. The silkworms when they are hungry start eating very actively as soon as fresh leaves are given.

2.5. Bed Cleaning

Removing the old mulberry leaves, faecal matter of silkworms, any dead or unhealthy silkworms, etc. from the rearing bed is called bead cleaning. Silkworms are fed with more quantity of mulberry leaves than their eating capacity, thus unconsumed leaves which are unfit for eating remain in the tray at the end of each feed. Besides the excreta of worms forms a thick bed. Out of the total weight of leaf that has taken as food, three-fifth is excreted and only two-fifth is being assimilated by the silkworm. The piling of litter makes the beds moist and this releases process of fermentation liberating injurious gases and also favours multiplication of pathogens. All the above factors are harmful to the worms. Hence, periodic cleaning of the larval bed is of prime importance during silkworm rearing.

2.5.1 Frequency of Cleaning

Cleaning involves labour and frequent cleaning is not advisable as it increases the rearing expenses and reduces the profit of the silkworm rearer (Table 2.5). While cleaning, there is a scope for loss of worms especially during chawki rearing. So it is advisable to follow bed cleaning in the following manner during silkworm rearing at each instar of chawki silkworms.

Table 2.5. Instar wise frequency of bed cleaning

Sl.No.	Stage of the worms	Number of times
1	I instar	One time
2	II instar	Two times (Once just after the 1st moult and again before setting for 2nd moult).
3	III instar	Three times (once after 2nd moult, once in the middle of 3rd age and once just before setting for 4th moult

2.5.2 Method of Cleaning

For cleaning of beds husk, nets, cut straw are used. There are three methods of cleaning.

1. Cleaning with husk
2. Cleaning with Net.
3. Cleaning with husk and net.

2.5.2. (a) Cleaning with husk

For this method charred husk or paddy husk is sprinkled evenly over the bed of silkworms. This sprinkling of husk is carried just prior to first feeding early in the morning. The worms crawl through the husk layer to reach the leaves. During the second feeding the bed is ready for cleaning.

All the worms are collected together by a brush and transferred into another fresh tray.

The natural paddy husk is too big and too thick for two ages. Thereby the worms cannot come up. For these ages, husk should be broken into small pieces before it is used. Care should be taken to avoid dust of husk as it spoils the leaves fed to the worms.

2.5.2. (b) Cleaning with net

In this process, a net with mesh suited to the size of the worms are used. During the process of cleaning the net is spread over the bed just prior to the first feeding early in the morning. Worms crawl through the meshes and feed on the leaves. Then it is cleaned after second feeding (Fig. 2.9.). During the process along with the leaves, worms are transferred to the fresh rearing tray. It is very simple method and requires little labour. However it is not convenient for the purpose of spacing. The mesh sizes of different cleaning nets are

First and second instar…………….. 2 mm2
Third instar …………….......... 10 mm2

This method is so simple, easy to adopt, requires less labour and this practice is quite common with farmers and in chawki rearing centers.

Fig. 2.9. Bed cleaning using nets

2.5.3. (c) Combined husk and net method

In the process of bed cleaning both husk and net are used. First a thin layer of paddy husk is sprinkled over the bed and a suitable net is spread. Then after two feedings the worms are transferred along with the net into another tray. This process is more expensive and not suitable practice for providing of spacing. Further, at present this practice is not observed with the most of the farmers.

2.6 Spacing

As the larvae grow in size, they require more bed area. Overcrowding of the silkworms leads to unnecessary competition for the available food and space, which weaken the worms to a great extent. Spacing is an important aspect which needs maximum care. Overcrowded bed does not permit free and complete growth of the worms. It is very important for the vigorous and full growth of worms. As the worms grow in size and weight, the bed density increases leading to overcrowding. Such condition in the early stage leads to poor growth. There should be uniform distribution of the larvae in the bed. Therefore the population density in the rearing bed should be regulated to ideal condition. In rearing most of the failures are because of improper spacing in the bed. As the age of the worms increases, the length and breadth of the rearing bed increases (Table 2.6).

Table 2.6 Length and breadth of worms**.**

Stage	Increase in length	Increase in breath
I	2 ½ times that of newly hatched worms	2 times that of newly hatched worms
II	4 - 5 times that of newly hatched worms	4 times that of newly hatched worms
III	7-10 times that of newly hatched worms	6-7 times that of newly hatched worms

Table 2.7 Chawki bed space for 100 Dfls (60,000 larvae)

Instar	Multi x Bivoltine (Cross Breed) (Sq.ft.)		Bi x Bi hybrids (Sq.ft.)	
	Start	End	Start	End
I	4	16	4	18
II	16	48	18	60
III	48	180	60	210

Insufficient rearing bed leads to overcrowding and less space for movement and for feeding of the worms. Crowding condition favours increase in gases, heat and fermentation of fecal matter. Fermentation process particularly happens during early stages when temperature and humidity are high. In this condition worms do not feed freely. This results in unequal and unhealthy growth of larvae. The worms become weak and easily susceptible to various diseases. The commercial characters are also severely affected. Table 2.7 indicates the need to expand the rearing beds from time to time. Thereby orderly growth of silkworm can be expected.

Sparse spacing of worms is not desirable as it leads to wastage of leaves, labour and requires more investment and economically also not viable. In normal condition the space is doubled or tripled from first instar to third instar. On the whole, rearing space has to be increased by 80-100 times from brushing to ripening of worms or spinning. For cross breeds (100 dfls) bed area required is around 30 sq.ft at the end of 1st instar and 60 sq.ft at the end of second instar and for bivoltine hybrids the area is 36 sq.ft and 72 sq.ft respectively.

2.6.1 Time and frequency of spacing

Silkworms develop very rapidly from instar to instar and increase several times their original weight and size in each instar. The rate of increase varies between the seasons and races. To provide more space for the growing worms, the rearing space has to be extended at each stage. Providing of enough space to the silkworms should go along with the development of worms. Therefore worms are spaced at each feeding. The development of worms is most rapid in first age. Thus spacing is done frequently, and it is always advantageous to combine spacing with cleaning. This saves labour also. In further instars spacing is combined with cleaning. When the humidity and temperature are higher than optimum the worms are spaced. The trays are kept in alternate shelves for free circulation of air. The spacing can be done separately or in combination with bed cleaning. Among these two the latter method is quite convenient and easy for judging the required spacing. It facilitates in less handling and in turn less disturbance to the silkworms.

2.7. Moulting

The silkworm larval life has five instars and four moults. The larva casts off its skin to accommodate the body growth. This is called moulting (Fig. 2.10 and 2.11). The silkworm larvae attain their maximum body growth in a particular instar and as a result body becomes stout and shiny and is amber coloured. These two characters are seen in larva towards the approach of moulting. In relation to the size of the body, the head of the worm appears small and dark. This is the time for bed cleaning and to provide optimum spacing. Soon after worms are about to settle for moult and are given one or two feeds which helps to reduce the humidity and favours uniform moulting.

In high humid conditions a thin layer of lime powder is dusted which prevents early moulted larva from eating leaf, favouring uniform growth. Feeding has to be stopped when all the larvae settle for moult. The first moult period in between 20 - 24 hrs, second and third age larvae require one day. Moulting is a very sensitive process in the life cycle of silkworms during which time the worm does not feed but wiggles out of the old skin and comes out with a new and soft skin.

After moulting, the worms head is bigger in relation to the body size. It is rusty in colour, less shiny because of loose skin. The first feeding of the new instar starts only after almost all worms come out of moult. Any irregularity in setting for moult is noticed; all such late larvae are segregated by net feeding and reared as second batch or otherwise discarded. Care should be taken to keep the bed dry during moult for which slaked lime needs to be dusted. This facilitates the larvae to wriggle out of the old skin.

As the silkworm grows in size, its body becomes too tight and brittle to hold the body. As a result of this, its movement becomes difficult and mouth parts look small compared to its head. At this stage silkworm stops feeding and movement is reduced and sheds its old skin. The process of shedding its old skin is known as moulting. The first moult occurs three days after brushing and second one after another 2-2½ days. The duration of each moult is for about 20 - 24hrs. As the larva approaches moulting stage, its body becomes lustrous, shining, prothoracic segment become bulged, head becomes narrow, pointed and black, losses appetite and becomes weak. As the worms prepare for moult the leaves are cut in to smaller size and thinly spread to meet the requirement of the fewer feeding worms. Paraffin paper and wet paper, if any is removed. When 85-90% of worms settle for moult feeding is stopped and slaked lime is sprinkled over to dry the rearing bed and adequate ventilation is provided. When 95% of the worms come out of moult the bed disinfectant (Vijetha / Ankush) is dusted and fed after half an hour gap. The moulted larvae looks ash colored with broader mouth portion and feed actively.

Fig.2.10. First moult worms

Fig.2.11. Second moult worms

2.8 Chawki Rearing methods

There are three methods of rearing but in all methods importance is given to the maintenance of leaf quality, humidity, temperature so as to ensure vigorous and healthy development of the silkworms.

Commonly the following three rearing methods are followed.

1. Paraffin paper rearing
2. Box rearing
3. Co-operative rearing

With the advancement of sericulture R & D efforts and technological awareness two types of new methods have been identified for successful rearing of chawki silkworms. These efforts have developed to simplify rearing, increase productivity and to reduce the cost of production. These are Isolation chamber method and Blue polythene sheet method.

2.8.1. Paraffin paper rearing

It is a quite common practice with the farmers. Generally a good quality paraffin paper is used as a bottom layer and as a cover for the rearing beds in the usual rearing trays (Fig. 2.12). The objective is to maintain the optimum humidity in the bed and to keep the leaves fresh for a longer period by preventing the moisture loss. The paraffin paper should be taken out 30 minutes prior to feeding. This allows supply of fresh air to the silkworms and eliminates toxic gases accumulated in the bed. When the worms settle for moult, paraffin paper is not necessary. Further the bed must be dry during moult. A thin layer of lime powder is sprinkled over the bed which helps to keep the bed dry.

Under this method of rearing, a sheet of paraffin paper is spread on the base of the rearing tray and the silkworms are reared on this sheet and under another. In between the sheets on all the sides of the tray, wet foams are placed to maintain the required humidity during rearing.This method is practiced when temperature and humidity are lower. Wooden or plastic trays of 4’ x 3’ x 4” or 3’x 2’x 4” are used to prevent loss of moisture from the leaves and maintained them fresh, the worms are maintained on a paraffin paper in the rearing tray and after feeding the bed is covered with another sheet of paraffin paper. The rearing trays are piled up one above the other on small stand altogether looking like a box and therefore called box method of chawki rearing.

Fig. 2.12. Chawki Rearing under paraffin paper method

In high humid areas rearing of young age worms under this method, there is a scope for occurance of muscardine disease incidence. To avoid this slaked lime is recommended to reduce the humidity and to minimize the pathogenicity.

2.8.2 Box rearing

In this method specially made boxes are used for rearing. The boxes may be with or without lids.

(a). Rearing boxes with lids.

It completely resembles the paraffin paper method. After preparation of bed a lid is placed on the box and later arranged in the shelves. In third instar lids are not necessary. When the larvae settle for moult, the paraffin paper, wet foams and the lids are removed to keep the bed dry.

(**b). Rearing in Boxes without lids.**

This rearing again resembles paraffin method. The wooden boxes of uniform size with 10 - 15cm deep are used. After preparing the rearing bed the boxes are piled one over the other for rearing first instar. For rearing second and third instar larvae, a space of 2-3 cm between the boxes is made for ventilation. The boxes are kept open for at least 30 minutes prior to each feeding. It must be completely open when larvae start settling for moult (Fig. 2.13).

Fig. 2.13. Box Rearing

2.8.3 Co-operative rearing

The silkworms are to be reared properly during younger stage, if not the silkworms are prone to diseases which leads to crop failures. Facilities for maintenance of required temperature and humidity, supply of suitable leaves and appropriate handling of delicate worms, demand technical skills which may not be available with poor and uneducated farmers. Further small scale silkworm rearers cannot afford the equipments necessary to provide the ideal condition for young age silkworms. As the farmers have realized the advantage of buying chawki worms there is more scope for entrepreneurs to set exclusive chawki rearing centers to promote sericulture.

If the silkworms are not reared properly in the young stages they are prone to diseases in later instar, resulting in crop failures. Besides this rearers are not able to afford the necessary equipment for silkworm rearing under ideal conditions. In order to overcome all these problems co-operative rearing has been organized to provide technical assistance, ideal conditions etc. The rearing is conducted up to second or third moult.

The chawki rearing centers are provided with ideal rearing houses with all the necessary equipment. The total rearings are supervised by technical experts. Silkworm rearing is provided from a single mulberry garden which ensures uniform quality of leaf. Because of ideal conditions and quality leaf silkworm growth is vigorous and healthy. This ensures harvesting of good crop and increased income to the rearer. The silkworms are reared in large scale reducing the expenditure which is charged to the rearer. Further the rearer need not conduct chawki rearing. Generally co-operative rearing centers have a capacity to rear 200 to 500 boxes (each box contains 20,000 eggs) up to third moult or double the size up to second moult. It is popular in Japan and 90 percent rearings are carried up to third moult in co-operative centers.

Advantages

- It saves labour and provides scope for doing other work.
- It ensures stable rearing conditions and high cocoon quality.
- Raising of healthy and robust young age silkworms ensures stabilization of crop and increase in cocoon yield.
- Producing uniform and healthy silkworm larvae and cocoon.
- During rearing, there is reduction in missing percentage of larvae and hence the crop yield is increased.
- Reducing the chances of contamination and spread of diseases.
- Disease control can be carried out more effectively.
- It reduces expenditure and lowers the cost of production.

2.8.4. Isolation Chamber

The rearing of chawki silkworms requires ideal environmental conditions, good quality leaf and appropriate technologies. It may be difficult to maintain the required environmental conditions as some farmers rearing in dwelling house. Therefore, this method has been developed to provide better environmental conditions and hygiene at the farmers level with low input cost. The isolation chamber can easily satisfy the average farmer as it can be accommodated inside their dwelling house. The isolation chamber could be made by using wood or brick.

The isolation chamber is of 6’height, 4’width and 5’depth with a single front door (5.5 ‘height x 4’width) having a glass window of 6’’ x 9”. Two bottom (4”x 9”) and top ventilators (9”dia) with sliding doors for regulation are provided. Thermostatically controlled blowing type room heater maintains the required temperature and humidity.

Advantages of the method

1. Optimum temperature and humidity can be effectively maintained with minimum fluctuations.
2. Moisture loss in the leaf is minimized.
3. Larval growth and moulting behaviour is uniform.
4. Larval duration is reduced.
5. Crop stability improves.
6. A chance of contamination is minimized.

2.8.5. Blue polythene sheet Method

To maintain optimum humidity conditions, use of paraffin paper, wet foam pads and box rearing method are quite practiced in tropical conditions. Because of the high cost and non-availability of paraffin paper, use of blue polythene sheet is found more advantageous. It is used in silkworm beds in place of paraffin paper for bottom cover. It is much cheaper and durable than paraffin paper. The polythene sheet should be of 400 gauge. During high humid conditions, wet foam pad and bottom sheet can be dispensed with. Minimum of 3 inch gap should be maintained in between covering sheets and rearing bed.

Advantages

1. The polythene sheets are easily available.
2. These sheets could be washed and disinfected.
3. It could be reused for many crops.
4. It reduces the input cost.

2.9 Chawki Rearing Centers (CRC's)

Rearing of young age silkworms required technical skill which is quite inadequate with the common sericulturists. Further, many sericulturists may not have the necessary equipment to rear the young age silkworms under ideal conditions. These difficulties could be reduced to a great extent, if rearing of young age worms is conducted in Chawki Rearing Centers. Rearing of young age larva in CRC is conducted by trained technicians in a common place (Fig. 2.14 & 2.15.), which is provided with the requisite equipment for maintaining the optimum temperature and humidity. The leaf required for the young age silkworms is procured from well-maintained chawki garden. The worms are distributed (Fig. 2.16) to the farmers when they have settled for second moult or out of moult.

Farmers generally purchase worms of about 2nd Moult or resumed from 2nd moult from Chawki Rearing Centers (CRCs) and rear them for remaining period till the formation of cocoons. Here, Chawki' refers to the young silkworms reared from hatching to 2nd moult stage. The quality of chawki worms leads to harvesting of successful cocoon crops. The success of silkworm rearing and productivity depends on technology practiced in rearing particularly the young age silkworms.

Promotion of CRCs through the private sector is one of the objectives of National Sericulture Project (NSP). It is assumed that the supply of good quality chawki worms to the farmers would go a long way in reducing mortality rate of silkworms and in improving their vigour and ensuring better yield such as:

- On an average it facilitates an incremental yield of about 5 - 10 kg per 100 DFL's.
- It saves cost on recurring equipments and disinfectants.
- The risk factor involved in chawki rearing is eliminated.
- It saves labour, time up to 8 days per crop to attend other activities by the farmers.
- A sufficient time gap is made available to the rearer for carrying out disinfection of the shed and the equipments.

Fig.2.14 Government Chawki Rearing Center

Fig.2.15. View of commercial CRC

Fig.2.16. Chawki Silkworms transportation box (50 Dfls)

2.10. Artificial Diet

Sericulture depends on rearing of silkworm on mulberry leaves and it can be stated that silk production is directly correlated with larval growth. The production of mulberry leaves both in terms of quality and quantity change due to different climatic factors and field practices. Under the Indian tropical conditions the moisture content and levels of different nutrients in the mulberry leaf vary depending on the age of the garden, season, irrigation status, mulberry variety etc. and as such feed quality is not consistent.

Artificial diet has come into picture to solve such problems in particular. It contains ingredients like Soya bean flour, ground nut cake etc., that contain carbohydrates, proteins, vitamins and minerals to fulfill the complete nutritional requirements of the young silkworms. Further it also contains certain amount of mulberry leaf powder containing attracting factors and biting factors. In India, Central Sericulture Research and Training Institute (CSR&TI), Mysore has developed '*Nutrid*' a semi synthetic diet for rearing of chawki silkworms. Rearing of chawki worms on artificial diet is called artificial diet rearing.

The growth and development of silkworm larvae and subsequently cocoon production are greatly influenced by quality leaf. Nearly 70 percent of the silk produced is directly derived from mulberry leaf proteins. Hence, silkworm should be fed abundantly with good quality mulberry leaves for the successful cocoon production and high yield of silk. Although mulberry (Morus sp.) leaf is considered as the traditional food for silkworm, but now a day's many attempts have been made to establish the usage of artificial diet. First time, artificial diet was used in Japan during 1977 for rearing of young larvae of the silkworm. The practical application of artificial diet in sericulture which has enabled to save enormous deal of labour for the rearing and the rearing young healthy larvae has rapidly expanded. Though many artificial diet have developed after extensive research, but it was observed that silkworm exhibits better growth rate and cocoon production when fed by mulberry leaves only. Although the use of artificial diet for the rearing of silkworms from the 1^{st} to 3^{rd} instars is important, this practice is limited to the rearing of silkworms from 1^{st} to 2^{nd} instars only. Under the optimum conditions, the chawki silkworms that are reared under artificial diet have the following advantages.

- Since the diet is consistent in nutrient values, a robust and healthy growth of chawki worms can be achieved in all seasons.
- Chawki activity could be carried out even in urban areas without any mulberry garden.
- It is free from all disease causing pathogens and the chances of contamination through chawki leaf and frequent human handling is minimized.
- Facilitates mechanization of chawki rearing activity and saves man power to a great extent.

It was generally considered that artificial diet could not be used for silkworm rearing throughout all the instars for silk production, due to the cost of the diet. However, with the breeding of polyphagous silkworms and the development of low cost artificial diets this practice may become possible.

Table 2.8. Standards for young age silkworm rearing (for 100 Dfls)

Larval Stage	**Age (days)**	**Feeding time**	**Leaf quantity (g)**	**To be followed**
I Instar 27-28^{O}C 80 - 90% RH	1	10 A.M 2 P.M 8 P.M	500	Expose layings from black box to light around 7AM. Brush the larvae around 9 AM using finely chopped tender fresh leaves.
	2	6 A.M 2 P.M 8 P.M	1,800	Spread the bed half an hour before feeding for drying.
	3	6 A.M 2 P.M 8 P.M	1,200	Spread the bed half an hour before feeding for drying. Observe for moulting, reduce the leaf size and quantity of leaf accordingly.
I moult	4	6 A.M 2 P.M	200	Stop feeding when about 90% of larvae settle for moult. Spread the bed gently and apply lime powder.
II Instar 26-28^{O}C 80-85% RH II moult	5	8 A.M 2 P.M 8 P.M	3,500	Feeding has to be given if more than 90% of the larvae are out of moult. Clean the bed using net and be cautious to avoid missing larvae.
	6	8 A.M 2 P.M 8 P.M	4,250	Spread the bed half an hour before feeding for drying.
	7	6 A.M 2 P.M 8 P.M	1,100	If the symptom of moulting is observed, reduce the leaf size and quantity, clean the bed before settling for moult.
	8	10 P.M 6 A.M 10 A.M		Feeding has to be stopped when more than 90% of larvae settle for moult. Spread the bed gently and apply lime.

Summary

- *Rearing of first two instars is called chawki rearing. These larvae are resistant to high temperature and humidity and grow well under optimum environment.*
- *Chawki rearing is a vital aspect of silkworm rearing and proper chawki rearing ensures successful cocoon crops.*
- *Different chawki rearing methods aims at preventing of leaf driage and maintenance of optimum temperature and humidity.*
- *Mulberry leaves are the sole food source for silkworms and the quality and quantity of leaves fed during rearing decides the crop success in sericulture.*
- *Leaf preservation is necessary to protect the nutritive values from time to time. Leaves are to be stored in leaf chamber or earthen pots.*
- *Proper feeding enables healthy growth of worms and however growth depends on the amount of mulberry ingested and digested.*
- *The worms are fed with chopped leaves according to their stage.*
- *Bed cleaning enables to remove waste leaf and excreta.*
- *Cleaning nets of 2 and 10 mm2 are used for bed cleaning.*
- *Spacing of worms facilitates proper growth.*
- *Commercial chawki rearing centers are playing important role to ensure crop success.*
- *To overcome the problems of varied nutrient conditions in mulberry leaf, artificial diet has been introduced. It is yet to be exploited commercially in India.*

Short Answer Type Questions

1. Define chawki rearing.
2. Which mulberry leaves are suitable for chawki worms?
3. What is glossy leaf?
4. What is the frequency of feeding during chawki rearing ?
5. Define bed cleaning.
6. Mention methods of bed cleaning.
7. Define spacing.
8. Define moulting.
9. How do you identify moulting worms?
10. What is the use of paraffin paper?
11. How many instars are there in larval stage?
12. List out various stages of feeding?
13. What is a Chawki rearing center?
14. Artificial diet

Long Answer Type Questions

1. Discuss about the importance of quality leaf in chawki rearing?
2. How do you select mulberry leaves for chawki worms?
3. Describe feeding aspects of chawki worms?
4. Describe different methods of bed cleaning.
5. Write about the importance of spacing in chawki rearing.
6. Describe methods of chawki rearing.
7. Write short notes on

(a) Spacing (b) Leaf chopping (c) Moulting

8. Write in details about the moulting and care to be taken during moult?
9. Write in detail about the commercial chawki rearing centers?
10. Write essay on artificial diet rearing of silkworms?

Practice Methods

1. Identify the glossy, tender leaves and preserve it (or) prepare herbarium.
2. Collect the moulting and out of moult worms and preserve it.
3. Prepare a chart for care of rearing silkworms during rainy season.
4. Visit commercial chawki rearing center and prepare your study report.

UNIT 3

Late Age Rearing

Structure

Learning Objectives

After studying this chapter you will be able to,

- Identify the different stages of late age silkworms.
- Know about the environmental requirement for rearing late age silkworms.
- Able to select different larval protection measures during rearing.
- Understand various late age silkworm rearing methods.
- Identify the ripening worms and their indications.
- Dissect silk glands.
- Explain and adopt the shoot rearing method with its advantages.

3.1. Introduction

Sericulture as an integral part of agriculture development which is the driving force for sustained economic growth of rural India. Of the various activities of Sericulture, the aspect of silkworm rearing is important ensuring higher returns. Though silkworm rearing activity is a single activity, it could be divided into 'Chawki' and 'Late age rearing' based on the feed and climate requirement. The rearing of grown up silkworms from fourth instar to spinning is termed as late age rearing and is usually completed in 14 – 16 days. Silkworms attains significant growth during this stage representing more than 94% of the leaf consumption, 133 times increment in body size, 125 times increment in body weight and nearly 1000 times increment in silk gland weight. Late age rearing requires proper ventilation. Maximum growth and survival influence the cocoon crop yield and this can be achieved only through scientific and skillful rearing of silkworms.

Rearing of fourth and fifth instar worms is called as late age or adult silkworm rearing. The late age silkworms moult or shed their skin two times *i.e.* the third and fourth moult to facilitate the growth of the larvae. These worms require less humidity and preferably low temperature when compared to early stages. This stage is the real feeding stage. The worms consume about 90 to 95% of the total feed. When chawki worms are reared perfectly, late age rearing is comparatively easy. As this is the final stage of rearing, worms are fed properly with quality leaves to get good crops.

Characteristics of late age silkworm:

- Low tolerance to high temperature, high humidity and poor ventilation.
- Out of total consumption of leaf, about 94% of the leaf is consumed during late age.
- Reduction in feeding affect the cocoon size and larval duration is prolonged.

3.2 Quality of mulberry leaf

The success of silkworm rearing mainly depends upon the quality of leaf. The 4th and 5th instar worms require less moisture content in the leaf than the chawki worms but the leaves should be nutritious. The late age worms are to be fed with medium and coarse leaf and these silkworms require nutritious mulberry leaf with less moisture content of 70 ± 5% and medium and coarse leaf harvested from 50 – 60 days old garden. After harvest, the leaf is transported to the rearing room, packed loosely in wet gunny bags or bamboo baskets covered by wet gunny cloth. In case of shoot feeding method, the shoots should be preserved vertically in separate room and covered with clean wet gunny cloth in semi-dark room with lower temperature. Harvested leaf can be stored in leaf chamber or in wet gunny cloth. The major varieties recommended for irrigated conditions are V1 and G4 and for rainfed conditions are S13, S34 and RFS175.

Late age worms are fed with bottom mature (dark green) leaves which are thick, soft and rich in protein and comparatively low moisture leaf. Too tender or over matured leaves are not fit for feeding. When the silkworms are fed with wilted, dusted and over matured and less nutritive leaves, results in slow growth of silkworms and become susceptible to diseases. Even if such silkworms reach spinning stage also, results in poor quality cocoons. From the 3rd day of the 5th stage, the silk glands of the worm develop vigorously. Therefore, they are fed with abundant good quality mulberry leaf. However the digestion rate is lower in late age worms than young worms.

In the spring, when air temperature falls suddenly at night, silkworms fell ill and cannot digest the mulberry. Therefore it is necessary to raise the temperature. The dose of feeding mulberry is increased slightly in the morning feed during day time when it is warm. According to the environmental condition the feeding quantity has to be regulated.

3.3 Leaf Selection

Mulberry for late age worms are also selected by largest glossy leaf method which is described in chapter 2. In glossy leaf method selection, the mature leaves remained on the mulberry twigs after chawki rearing are fed to IV and V instar worms harvesting from top to bottom. At present most of the farmers are practicing shoot rearing in such cases whole shoots are harvested and fed to late age silkworms.

3.4. Feeding Schedules

The mulberry leaf has to be fed to the silkworms as per the fixed gap so that the leaf is supplied to the silkworms with required quality for which the fixed schedules or timings are followed during the silkworm rearing. These schedules may vary based on the seasons and type of rearing.

3.4.1. Feeding

The importance of feeding and growth of the worms are detailed in chapter 2**.** Depending on the environmental conditions, frequency of feeding is decided. Generally two feedings per day in shoot rearing method and 2 – 3 feedings in leaf feeding is followed at equal intervals. In the present conditions with the technological advancement and awareness by the farmers, the frequency of feedings is brought down to 2 feedings / day even with leaf feeding. The quantity of feed fixed for each instar should not be reduced. However, it is desirable to increase or decrease the frequency in rainy and summer season without affecting the quantum of feed.

3.4.2 Preparation of leaves for feeding late age worms

Chopping of leaves for feeding is not essential to late age worms. Feeding of leaves depends on leaf harvest. In case of leaf plucking whole leaf can be given to IV and V instars. However in rainy season depending on the humidity, leaf can be cut into two bits before feeding the worms. In case of shoot harvest, it is cut in to convenient size shoots to accommodate in the rearing tray. The quantity of leaf required for rearing of 100 layings from IV to V instar is given in Table 3.1.

Table 3.1. Required quantity of mulberry leaves for 100 Dfls

Sl. No.	Stage of the worms	Leaf feeding system		Shoot feeding system	
		Multi x Bi (Kgs)	CSR Hybrids (Kgs)	Multi x Bi (Kgs)	CSR Hybrids (Kgs)
1	III	45	65	94	138
2	IV	140	196	235	398
3	V	800	1120	1335	2240

3.5 Bed Cleaning

It is a process to remove waste and harmful material found in the rearing bed. In tray rearing, bed cleaning is done daily during IV and V instars. Generally bed cleaning is preferable after first feeding. The net size of 20 mm^2 is spread prior to feeding. The bed cleaning is done before the second feed where the worms along with net and leaves are transferred into a fresh tray. The fecal material and left over leaf are put into manure pit. While cleaning, attention should be paid to keep the rearing room, floor and premises clean and tidy. Methods of cleaning are described in chapter 2.

Fig. 3.1. Bed cleaning under shoot rearing method using ropes

In shoot feeding method, bed cleaning is mostly avoided except when humidity is very high. When cleaning of bed is required, it is done by rope method or net method. In rope method, ropes of 8 feet length are spread parallel to one another on the rearing bed leaving a margin of one foot on both sides. After two feedings, when most of the larvae climb and reach the surface of the bed, both the ends of the ropes are lifted to gather the shoots with larvae in the center so as to make a bundle which is kept at another place of the same rack. This helps in separating the old bed easily without damaging the larvae (Fig. 3.1.).

3.6. Spacing

To facilitate the growth of the larvae, timely and sufficient leaf quantity has to be fed to the silkworms. Spacing influences the health of the larvae and also the economics of silkworm rearing. Overcrowding of the silkworms leads to insufficient consumption of leaves and larvae become small and spin smaller sized cocoons, whereas wider spacing lead to leaf wastage and higher leaf cocoon ratio. Therefore optimum spacing needs to be provided as per the stage of the silkworms.

Good spacing of worms in the rearing beds plays a vital role for the success of silkworm crop and improvement of cocoon quality (Table 3.2). During IV and V instars more than 93% of the total feed is given. Besides all precautions taken while feeding the worms by adequate leaves, crowded condition leads to under nourishment and uneven development of the worms. Further it favours the incidence of disease and results in inferior quality cocoons. Spacing should be increased simultaneously with the growth of the larvae. It is better to provide required space to the worms during bed cleaning. The late age worms are spaced every day.

Table 3.2 Recommended spacing for 100 Dfls

Stage of the worm	Multi x Bi (Sq.ft)				CSR Hybrids (Sq.ft)			
	Leaf feeding system		Shoot feeding system		Leaf feeding system		Shoot feeding system	
	Start	End	Start	End	Start	End	Start	End
III	45	90	45	90	65	150	72	210
IV	90	180	90	200	150	300	210	420
V	180	360	200	400	300	600	420	800

3.7 Moulting

In late age rearing, silkworm undergoes moulting for two times, the third and fourth moult for shedding the skin. The moulting duration in fourth moult is longer for about 30 hours. When larvae show moulting symptoms (Fig. 3.2.), feeding quantity should be reduced and rearing bed should be made dry. When all the worms settle for moult, a thin layer of slaked lime is dusted on the rearing bed which facilitates quick drying of bed and also prevents early moulted larvae from eating. Care has to be taken during moult and any mishandling may lead to irregular moulting which will affect larval health leading to inferior cocoon quality.

The duration of moulting is prolonged when compared to first three moults. When the worms are settling for moult, the bed is spread to a thin layer. This spreading enables to dry the left over leaves and also provides low humidity. If the rearing room humidity is high, a thin layer of lime is applied after the last feed.

Fig.3.2. Larvae under 4^{th} moult

Environmental conditions

Silkworm is one of the most domesticated insects, which produces luxuriant silk thread in the form of cocoon by consuming mulberry leaves during larval period. The growth and development of silkworm is greatly influenced by environmental conditions such as temperature, humidity, air current and light apart from rearing seasons, quality mulberry leaf and genetic constitution of silkworm strains (Table 3.3).

Temperature: The optimum temperature required for late age silkworms are 24 - 26ºc. Temperature plays a vital role on the growth of the silkworms. As silkworms are cold-blooded animals, temperature will have a direct effect on various physiological activities. The temperature has a direct correlation with the growth of silkworms and wide fluctuation of temperature is harmful to the development of silkworm. The increase in temperature raises physiological functions and with a fall in temperature, the physiological activities are decreased. Increase in temperature during silkworm rearing particularly in late instars accelerates larval growth and shortens the larval period. On the other hand, at low temperature, the growth is slow and larval period is prolonged. Generally, the room temperature is low during winter and rainy season, which could be regulated by heating the room with electric heaters or charcoal fire or locally available devices to increase the temperature.

Humidity: Comparatively low humidity in the range of 65 - 70% is required. Humidity plays a vital role in silkworm rearing and its role is both direct and indirect. The combined effect of both temperature and humidity largely determines the satisfactory growth of the silkworms and production of good-quality cocoons. It directly influences the physiological functions of the silkworm. Humidity also indirectly influences the rate of drying of the leaves in the silkworms rearing beds. Under dry conditions especially winter and summer the leaves dry very fast and consumption by larvae will be less. This affects growth of the larvae and results in wastage of leaf in the rearing bed. Retarded growth of young larvae makes them weak and susceptible to diseases. So the required humidity needs to be provided by using humidifiers, in the rearing house and keep the verandah cool around the rearing house and by making cooling arrangements around the rearing house.

Table 3.3. Temperature and humidity requirement during late age silkworm rearing

Stage of the silkworms	Temperature (℃)	Humidity (%)
Fourth Instar	24 - 26	70 - 75
Fourth Instar	24 - 25°	65- 70

Air current: Air current has a tremendous effect and a major impact on late age silkworm rearing. The air which gets polluted in the rearing house through various activities is to be removed. This is possible only when there is good ventilation. Better ventilation also helps in regulation of rearing temperature and humidity.

Light: Light has indirect effect on silkworm and the silkworms are photosensitive and prefer dim light (15 - 30 lux). The late age silkworms show optimum uniform growth at a photoperiod of 16 hrs light and 8 hrs of darkness. However some farmers, uses high voltage bulbs to increase the temperature in the rearing house which is not a correct practice as the silkworms prefers only dim light.

3.8. Late Age Rearing Methods

The second stage silkworms after moult are transferred to late age rearing house. Rearing of late age silkworms (Fig. 3.3) is conducted by different methods depending upon the space availability, economic condition of farmer and availability of labour. Accordingly, three popular methods are in vogue.

1. Shelf rearing or Tray rearing
2. Floor rearing

3. Shoot rearing

Fig.3.3. Late age silkworms

3.8.1 Shelf rearing

Rearing is conducted in wooden/ bamboo trays (Fig. 3.4) of convenient size (3 - 4 ft. diameter) and fed individual mulberry leaves plucked from the mulberry bushes. The round bamboo rearing trays are arranged in stand made of wood/bamboo/iron with 10-12 tiers. The stands are arranged in rows leaving a convenient apace for attending cleaning and feeding. Generally round bamboo trays are used for this method. In each stand ten trays are arranged. The worms are fed with individual leaves. Three or four feeds are given per day and nets are used for cleaning.

Though tray rearing is more labour intensive for various activities like, plucking, feeding, bed cleaning the tray rearing is very popular with small scale and marginal farmers, as it needs less space for conducting rearing. This method is common in rearing-cum-dwelling houses. Feeding is done 3 times every day and cleaning of the rearing bed, removing of old leaves and litter is done every day .Cleaning of bed is done using nylon nets of mesh size 2"x 2". Rearing bed space is maintained at each instar depending on the silkworm breed.

Advantages

1. More worms can be reared in a limited area.
2. An overall view of all the trays is possible
3. Required air and light are available.

Disadvantages

1. More labour are required
2. Care should be taken for proper spacing
3. Cost of production is more.

Fig 3.4. Shelf Rearing

3.8.2. Floor Rearing

This method is followed traditionally in Kashmir and some parts of China (Fig. 3.5.) wherein rearing is conducted on the floor using mulberry shoots/branches in rearing bed of 5 feet width and as long as rearing room is made on either side of the floor with an old newspaper. Before spreading the newspaper, thin layer of lime is dusted on the floor to prevent the attack from ants. Feeding is done as in shoot feeding method and no cleaning of bed is practiced. Since no rearing racks are used for rearing, it is highly economical and hygienic. But the disadvantages are that, more floor area is required than tray and shoot rearing.

Advantages

1. Saving on labour expenses thus reduces cost of production
2. Saves time in feeding, cleaning and spacing.
3. Cost of trays and maintenance are totally eliminated.
4. More number of worms can be reared.
5. Silkworm growth and disease incidence can be observed easily.

Fig 3.5. Floor Rearing Method

3.8.3. Shoot Rearing

It is most economical method of all and resembles floor rearing. This method of rearing can be carried outdoor if the environmental conditions are favourable, especially temperature. In shoot rearing (Fig. 3.6) whole shoot with mulberry leaves are used for feeding the silkworms. A shoot rack of 5 ft. width and as long as rearing house with 3 - 5 tiers are used for rearing silkworms. The gap between the tiers is kept at 2 feet to facilitate easy feeding of larvae. The height of the rearing rack will be 6-7 feet and the bottom tier will be one feet above the ground level. Shoot rearing racks, are made of wood, iron or bamboo and can be easily assembled by the farmers, if more than 3 tier system is followed, it is difficult to feed the silkworms but more larvae can be accommodated in the rearing house. While assembling the rack a distance of 2 feet is made between the wall and the rack and 4 feet between the racks so that sufficient works space is available to work in the rearing house.

The worms are fed with big shoots. In every feed the larvae keep moving upwards to consume mulberry leaves. Due to shoot feeding the food is distributed in three dimensions favouring better aeration of rearing beds. Thus it is possible to accommodate 50% more worms per unit area. The rearing activates especially cleaning is reduced. It requires only one cleaning each in fourth and fifth instar. Ropes of convenient length are spread parallel to each other lengthwise on the bed and after two, three feeds when worms have crawled on to new branches, the bed is held by ropes is rolled into loose bundles by cutting the ropes for every 2 mts. After cleaning rolled bundles are spread on to the rearing beds. Thus labour requirements for cleaning and feeding are minimized. At present most of the farmers are attracted towards sericulture and rearing of silkworm has become so easy due to the introduction of shoot rearing method. Most of the farmers are successfully following even with 7 – 8 tiers and 10 feet width irrespective of the length of the shoot. In the present scenario this method has been very well established with most of the sericulturists.

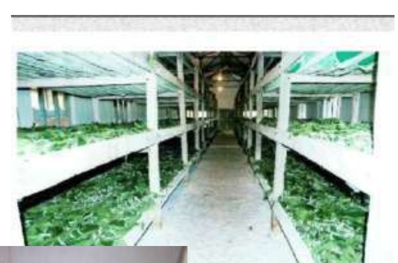




Fig.3.6. Shoot rearing under progress

Advantages

1. Labour requirement is reduced to 60% in IV instar and 50% in V instar.
2. Leaf saving is about 25% in IV age and 10% in V age.
3. Provision for indoor and outdoor rearing.
4. Better aeration of rearing beds.
5. Three dimensional feeding reduces leaf wastage.
6. Accommodates 50% more worms per unit area.
7. Cleaning and feeding time is minimized.
8. Rearing activities are made easy.

Summary

- *Rearing of IV, V instar worms is called as late age rearing.*
- *Worms are fed with mature, thick, rich in protein and low moisture mulberry leaves.*
- *About 94% of the total requirement of leaf is consumed by the larvae.*
- *Feeding schedule is worked out for different silkworm breeds giving the details of leaf requirement for different instars.*
- *Silkworms are provided with spacing based on the growth of late age worms. Because less bed spacing favours the incidence of the disease and yields inferior quality cocoons.*

- *On the other hand over spacing leads to wastage and higher leaf cocoon ratio. Thus spacing is carried along with bed cleaning.*
- *Fourth moult takes about 30 hrs based on the environmental conditions. When the worms are settling for moult the rearing bed is spread to a thin layer.*
- *Out of all the rearing methods, shoot rearing is well accepted by the farming community based on its advantages as the food is distributed in three dimension and favours to consume complete leaf.*

Short Answer Type Questions

1. What is late age silkworm rearing?
2. What type of mulberry leaf is fed to late age worms?
3. What is the size of leaf for feeding IV and V instar worms?
4. What is the time duration for IV moult?
5. What is the time required to complete 4^{th} and 5^{th} instar larval period?
6. Name the gases injurious to silk worms.
7. Mention the time schedule for feeding late age worms.

Long Answer Type Questions

i. Write about leaf quality required for late age silkworms.

ii. Write about mulberry quality and feeding schedules during late age silkworm rearing.

iii. Describe the various methods of late age silkworm rearing.

iv. Write short notes on

(a) Bed cleaning (b) Moulting

(c) Shelf rearing (d) Floor rearing

(e) Advantages of shelf rearing of silkworms.

For student practice

- Identify the matured leaves and preserve it (or) prepare herbarium.
- Dissect the Silkworm larva (V stage) and mount the silk glands.
- Prepare a model of silk gland by using a wax (or) cotton.
- Collect the Ripening worms and preserve it.
- Visit the sericulture farmers rearing houses and prepare a study / tour report.
- Prepare a report on the farmers experience on late age silkworm rearing.

UNIT 4

Spinning and Mounting

Structure

Learning Objectives

After studying this unit, students will be able to

- Identify the ripening worms and the symptoms of spinning.
- Understand the quality of cocoons, based on shell weight, cocoon weight and floss percentage
- Know the importance of temperature and humidity during spinning.
- Various devices for mounting of silkworms and their merits and demerits.
- Know about the byproducts of silkworm rearing and value addition.

4.1. Introduction

The ultimate object of silkworm rearing is to harvest cocoons for production of silk. Silkworm stops feeding at the end of fifth instar and starts building the cocoons. At the end of the 5^{th} instar, on the 6^{th} or 7^{th} day the silkworm shows less appetite, discharge soft light brown litter, skin become gradually transparent, larvae crawl about looking for a place to spin cocoons, which indicate that spinning stage has set in. The process of transferring matured larvae to a suitable frame to spin cocoons is called mounting. The frame used for mounting the matured silkworm larvae is called mountage.

Silkworm spins cocoons prior to pupation so as to protect itself from external and natural disturbances. Since it is the most critical period of metamorphosis, good mountages help the rearer to get good quality cocoons. The cocoons are to be harvested carefully and cleaned to eliminate bad cocoons otherwise it reduces the cost of cocoons. The quality of cocoons is decided based on the uniformity of the cocoons, cocoon weight, shell weight, shell ratio, floss percentage, number of cocoons per kg, number of defective cocoons, filament length, number of breaks, denier etc.

4.2 Ripening of Worms

Fifth instar worms feeding may last for five to seven days in case of multivoltine and bivoltine worms in the tropical areas and seven to nine days in case of bivoltine and univoltine races in sub-tropical areas. These worms stop feeding and called as mature larvae and starts spinning cocoons. As the contents in the digestive system become empty, the mature larvae appear differently. They are translucent and yellowish with fully formed silk glands and it is a clear indication that the worms are fully ripe and ready for mounting.

Ripened silkworms are to be picked on time so that all the mature worms able to spin cocoons successfully. The worms that are not picked on time or undue delay in picking can also be mistaken as diseased worms. Worms picked much before ripening may not spin the cocoons resulting in unnecessary crop losses at the final stage of rearing. Mature worms normally crawl towards the edges of the rearing tray by raising heads, in search of suitable support for spinning their cocoons. The process of picking ripe worms and keeping them on the mountage for spinning is called “mounting” of worms. To provide optimum conditions during mounting, the ripened silkworms are transferred to the devises called as mountages.

Silk Gland

Insect kingdom possesses certain adaptation or modifications of body organs to suit its mode of living. During this process insects show remarkable adaptations.. The silkworm, a lepidopteron insect has four life stages, one of which is totally inactive or resting or sleeping stage. The larval stage actively feeds on mulberry and grows to maximum size by passing through four moults. It is a preparatory stage where the animal stores the food material for the life stages and also develops certain organs which can protect the successive stages (pupa) by enclosing it.

The larvae develop a pair of silk glands which are modified labial glands and are capable of utilizing the haemolymph and amino acids for the synthesis of silk proteins. These proteins (sericin, fibroin) are utilized by the mature larvae for spinning the cocoons. At the end of fifth instar, the larva stops feeding and starts spinning the cocoons by oozing out silk from the spinneret and wraps itself while undergoing into pupal stage. The details pertaining to the structure of silk gland and silk synthesis along with properties are also discussed in the unit.

The development of silk gland and its growth depends on various factors such as breed, environment, rearing method and quality of the mulberry leaf. Among all, the nutrient value of the mulberry influences the silk production. Since the cocoons are the final end product in the silkworm rearing, care has to be taken for feeding optimum quantity and good quality leaf to the worms.

Structure of silk gland

Silk gland, a dermal gland derived from the invagination of the labial ectoderm. Silk gland is an important organ which produces silk as the source of cocoon fiber. A major part of this gland lies just below the alimentary canal. Glands are situated on the ventro-lateral sides of the mid- intestine and the posterior ends are blind. The gland is tubular and cylindrical in shape. At the anterior end, the two glands unite in head and connect with the spinneret of the labium. The gland is divided in to the anterior, middle and posterior parts. The anterior region is a straight tube opening at the fore end into the duct and posterior into the middle region. This part is not twisted and unlike the middle and posterior parts has no secretary function. The middle part is the largest, twisted in the shape of the letter 'S'. This region is again divided into three functionally different sections as fore, middle and hind parts. The fore part is slender or narrow at the starting but thickens quickly backwards. The middle is slender at posterior part. The posterior part is very long with many windings of uniform thickness, which are regulated by dermo-visceral muscles and the tracheae (Fig.4.1). A pair of Filippi's gland opens inside the silk gland at the joint of the anterior division of two glands and they secrete some viscous fluid.

The wall of silk gland is composed with the following layers.

a. Tunica perpuria having gland cells.
b. Tunica intima encloses lumen of the gland.

Tunica perpuria is uniform is structure. Tunica intima has a thick chitinous layer but only anterior division is shed at the time of moulting.

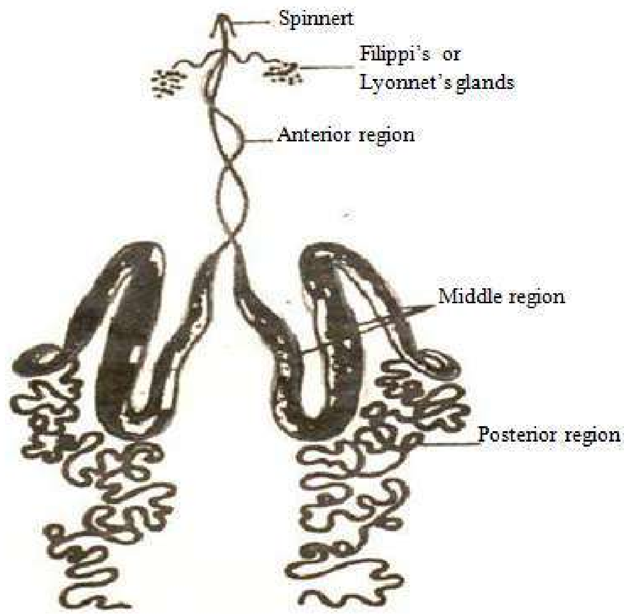


Fig. 4.1. Silk Gland

The silk gland grows very fast from the time of hatching to the final stage of mature larva. The growth involves swelling and increase of size of each cell but not increase in number of cells. The number of cells in the silk gland remained constant, with the cell division having been completed during the embryonic period.

The nuclei in the cells of the silk gland undergo change as the larvae develop from the young stage to the advanced stage. The nuclei is more or less circular in shape in freshly hatched larva and gradually branches out as the age increases. According to the age of the cells, the silk gland become larger which is secretory in function and become very active. Thus intensive branching of nuclei occupies most of the intracellular space. The oxygen for carrying metabolic activities is supplied from the tracheae distributed in the middle and posterior parts of the silk gland though anterior part has no tracheae.

When freshly hatched larvae start feeding on mulberry, the colour (yellow) pigment from the ingested mulberry leaves passes towards the alimentary canal and later into haemolymph. In the fifth instar the permeability of silk gland changes and the pigment permeates into its cells whereby silk glands become coloured. It is believed that the silk glands of the larvae which produce white cocoons do not become colored because the intestine of these larvae do not allow the permeation of the yellow and cocoon fiber pigments.

4.3 Process of Spinning

The ripened worms are mounted on the mountages and the worms pass out last excreta in semi- solid condition. Besides, when the humidity is high, excess body moisture is also eliminated as urine. After defecation, ripe worm starts spinning the cocoon by selecting a suitable place in the mountage. Silkworms synthesize silk by utilizing the amino acids present in the mulberry leaf. The ripen worm anchors itself first to the mountage by oozing a tiny droplet of silk fluid which immediately hardens and sticks to the mountage. Then by swinging the head continuously the silkworm first lays the foundation for the cocoons by weaving a primary web. The silkworm larvae rotates its head in the shape of 's' or ' 8' to spin the cocoon. The 's' shape is found in the outer layers of cocoon shell while the later type is usual in middle and inner layer. In this way the larvae forms layers of silk filaments around itself and finally wrapped in a compact shell (Fig.4.2).

The first formed filament *i.e.* primary web constitutes the floss of the cocoons and is not reelable. The floss in uni and bivoltine races is about 2 percent of weight of the cocoon. Whereas in multivoltines more than 10 percent floss is seen. The process of spinning continues about 1 to 2 days in multivoltines and 2 to 3 days in uni / bivoltines. After the compact shell of the cocoons is formed, the shrinking larva wraps itself in palade or gossamer layer. Finally the larva detaches itself from the cocoons shell to transform into pupa or chrysalis. This layer (gossamer / palade layer) does not form part of the main shell. It is also not reelable and becomes waste silk content.

Fig.4.2. During spinning Stage

4.4. Mounting

Mounting is the final and crucial stage in silkworm rearing. At the end of fifth age, the larvae reduce feeding, shrink in size, body becomes translucent and start crawling in the bed with raised head and releases wet fecal matter which indicates the initiation of spinning process. At the onset of spinning ‘Sampoorna’ or Chetana (Phyto-ecdysone hormone) is used for the hastening the spinning process. Once the spinning larvae appear in the bed, they have to be picked and put on the mountages. Care should be taken to protect the larvae / cocoons on mountage from ants / rodents. To provide optimum conditions during mounting period, mounting halls have been introduced where the farmers keep their mountages during the mounting period (Fig. 4.3). Depending on the material and structure of the cocooning frames the number of defective cocoons may increase. The features of good mountages are as follows.

- Mature worms can be easily induced to cocoon spinning
- Total mountage space can be efficiently used.
- Manufacturing can be easily and cheaply undertaken.

• Durable structures.

• Storage attached to the mountage can be easily removed.

• Material used is resistant to high moisture or wetness.

Fig.4.3 Mounting hall

4.5. Types of Mountages

Mature silkworms are collected and mounted on the mountages. This laborious job requires lot of skilled work. The ripe worms are identified and hand-picked by skilled labour and mounted on the mountages. This kind of mounting reduces the density of the mounted worms and occurrence of double cocoons. Diseased worms can also be eliminated. Worms can also be mounted using nets or green branches.

Branches of green leaves are placed over the rearing bed and when the worms crawl on to them, they are taken out and shaken over a mat, dislodged worms are put on mountages. Similarly a net is placed over the bed after feeding mature worms, which are no longer feeding and crawl upon to the nets which are collected for mounting as in branch method. In shoot rearing early maturing larvae (10-20%) are picked by hand and later remaining worms are collected by shaking the branches and later mounted. The most commonly used mountages in India for spinning cocoons of silkworms are bamboo chandrike, plastic collapsible mountage and rotary card board mountage.

Features of a good mountage

A mountage for producing good reelable cocoon should have the following minimum features.

- Sufficient cocooning space between frame works.
- The size of the cocooning space must be variable according to silkworm races. If the size is not favourable, double cocoons, cocoons printed with cocooning frame, deformed cocoons and soiled cocoons will increase. If the cocooning space is too narrow, it affects ventilation and result in poor reelability.
- Material used for mountage should be those which can make the reelability of cocoon filament better.
- Cheap, durable and easily available and possible to disinfect properly.
- Easy for storage when not being used.
- Ease to remove faeces and urine.

Bamboo chandrike

Bamboo chandrike are the traditional and the most commonly used appliances and more familiar to sericulture farmers (Fig. 4.4). It is made of bamboo spiral woven on a bamboo mat with two supporting bamboo sticks. The mat is of size 1.8 x 1.2 m. The spirals are made of bamboo tapes on the mat base with 5 - 6 cm width. Small holes are made on the mat base to provide ventilation. Matured silkworms are transferred to the chandrike @ 40-50 worms per sq. ft. After mounting, the chandrike is kept at a slanting back position to allow the urine to fall on the ground and to prevent the staining of cocoons.

Due to intensive bamboo industry in different parts of the country, the availability of bamboo chandrike has become easy and accessible to the farmers. Due to the simplicity of appliance and the procedures involved in its usage, the bamboo chandrike have become the most popular appliance for cocoon spinning.

Fig. 4.4. Bamboo chandrike

Plastic collapsible mountage:

These mountages are used mainly as self-mounting devices to save labour during spinning; it is being very well accepted and adopted by most of the farmers (Fig. 4.5.). It is made of plastic mesh having 11 folds of 2.2” height and placed in a wooden/ plastic tray of size 2’x 3’ for mounting the larvae. It can be stored by folding. Newspaper is spread at the bottom of the mountage for absorption of urine. Each mountage can hold 350 to 400 larvae for spinning. After mounting, strips of paddy straw or pieces of old newspaper are put on the mountage for providing anchorage to the spinning silkworms.

Plastic collapsible mountage can also be used for self-mounting. It can be directly placed on the rearing bed when the larvae start spinning by self-mounting. Then the mature larvae will crawl on to the mountage and spin cocoons. These mountages possess several advantages such as easy for handling, requires less space for storage and helps in maintaining hygienic condition. It is also easy for harvesting cocoons.


Fig.4.5. Plastic collapsible mountage

Rotary card board mountage:

This type of mountage designed mainly for bivoltine silkworms. The cocoons are more uniform with less number of defective cocoons. These are made of piece of cardboard assembled in a checkered pattern consisting of 13 rows and 12 sections each providing a total mounting space of 156 sections of size 4.5 x 3 x 3 cm. Each mountage is 55cm long, 40cm wide and 3cm deep and can be folded completely when not in use. Ten such mountages are fixed on a wooden rectangular frame using ten iron clamps on each of the four sides. The frame consists of two rectangular frames of size 120 x 58 cm and 115 x 44cm and is made of square wood of size 1 x 2 cm. Both the ends of shorter axis are fixed by an iron screw and the whole wooden frame can be hanged horizontally. It can also revolve by the horizontal short axis (Fig. 4.6. & 4.7). The wooden frame can be folded when not in use.

Each frame can hold 1560 worms for spinning, but only 80% is allowed to mount about 1300 larvae to provide sufficient spacing. For mounting matured larvae on this mountage first old newspaper spread on the floor and then the mountage is kept horizontally on the newspaper. Matured larvae are collected and transferred to the mountage. After 4-5 hours, when the larvae climb on the mountage, it is lifted from ground and suspended from the ceiling using iron hooks. Urine is collected at the bottom on gunny cloth which can be removed. The mountage get rotated as the larvae move and get, uniformly distributed till it starts spinning.

Rotary mountages are best among all the mountages, as it provides uniform spacing for all the larvae and avoid formation of double cocoons. Occurrence of defective cocoons is minimum and the reelability is better. But, the major demerits are its high cost and non- availability of good quality cardboard. About 35 – 40 mountages are required for 100 Dfls. These rotary mountages are delicate and they should be handled smoothly. The mountages should be preserved in a safe well ventilated place free of rats and termites.

Fig.4.6. Loading of ripened silkworms on to the rotary mountage

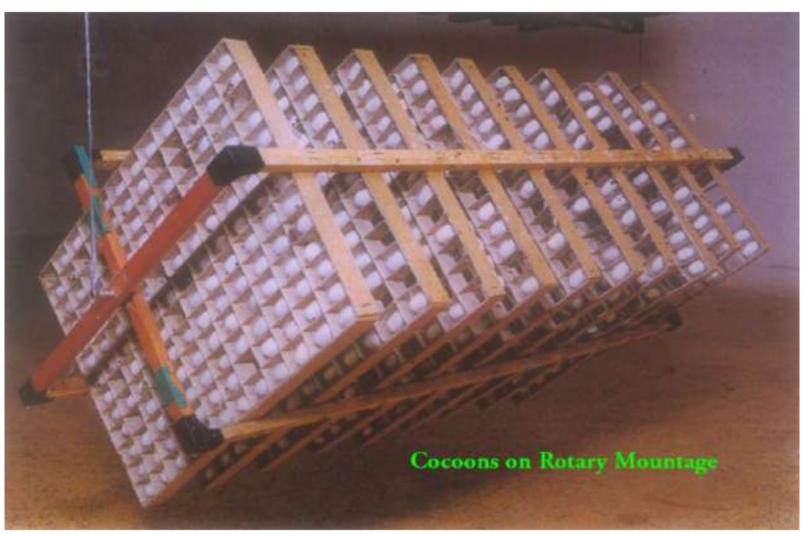


Fig.4.7. Cocoons on rotary mountage

4.5.1 Proper time of Mounting

It has negative effect on cocoon quality and quantity if mounting does not take place at right time. When immature worms are mounted, they die in the cocoon or their silk content in the cocoons will be low, resulting thin, double, stained cocoons which contribute to reduce cocoon quality in terms of reelability, fiber strength, colour, etc. These defects can be eliminated by ensuring the following.

- Silk worm body shape should be short and fat.
- Thoracic segments should be translucent.
- Faecal should be greenish, soft and irregular in shape.
- The worms should raise their head, thorax and should ooze out silk from their mouth parts.
- They should crawl around the rearing bed to find a place suitable for cocooning.

4.5.2 Methods of Mounting

Several types of mountages are available for cocoon spinning. However, at field level, the following three types of mountages and with the above discussed methods are predominantly used.

1. Hand Picking

Under this method, ripe worms are picked one by one by hand, collected in a tray and then transferred to the mountage. When one third of body of the silk worm becomes transparent, worms are picked up and put on the mountages. This method helps the rearer to mount the worms at right time. But labour expenses are high. Generally silkworms mature between 10 am and 3 pm. The worms become over mature producing cocoons of poor quality if the mounting is delayed with inadequate labour.

This is a method by which a properly matured larvae, i.e. when about one third of the body becomes transparent, is picked up one by one and put on a mountage. By this method, the silkworm can be mounted at the right time and is most favorable for getting good cocoons, but labour requirements are high causing economical loss. As silkworms become simultaneously mature between 10 AM to 3PM, some of the larvae may become over mature and produce poor quality cocoons, if the labour required for picking is immediately inadequate. However, simultaneous mounting of mature and immature larvae by picking one by one is undesirable for the purpose of getting good cocoons, as immature larvae mixed make bad cocoons though some labour for mounting can be saved.

2. Jobarai Method (Shaking of shoots)

It is better for shoot rearing. When worms (5 - 10%) mature, they are picked up by hands for mounting. The remaining worms are left till maturity. When 40-50 % of the worms have matured, along with the mulberry shoots and full of silkworms are shaked on the paper, vinyl sheets placed on a mat. Then these are covered with 2-3 layers of straw nets. After a gap of 30-40 minutes silkworms crawl up on to the net. These worms (roughly hundreds) are mounted on selected mountages (Fig. 4.8.). Rotary mountages are leaned against the wall by putting 130-140 worms on each frame. More number of worms is put on the top frame than the lower frame so as to fill all the frames evenly when suspended.

For collecting mature worms by shaking shoot method, worms are shaken down on a vinyl sheet under a shaking stand. Shaking can also be done manually by holding few shoots with worms or hitting the mulberry shoots lightly on a Jobarai table or using a vibrating machine. Silkworms thus collected are mixed with faces and remains of mulberry leafage. They may be separated by using a net. Jobarai method is ideal for shoot rearing method and 40% labour required for picking mature worms for mounting can be saved without affecting cocoon quality. For shaking of shoot a manual operated mature silkworm separator machine was develop. Under this method the following procedure is involved.

- When more than 40% worms mature, mounting can be done by "Jabarai" method.
- Take eight to ten mulberry shoots at a time for "Jabarai".
- Shake mulberry shoots gently from appropriate height on a newspaper.
- Fallen mature worms are collected for mounting.

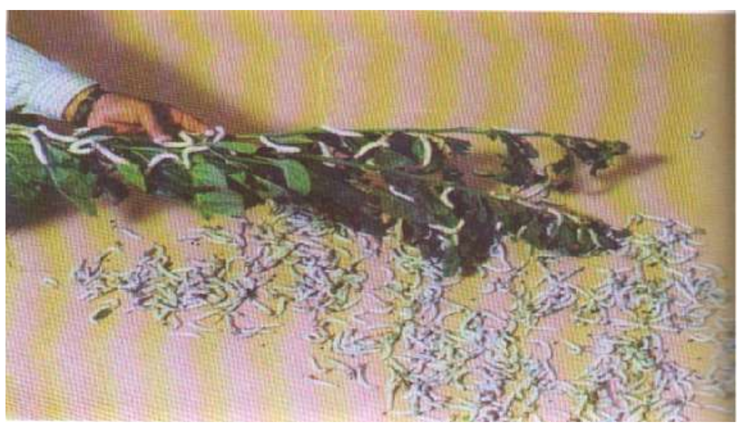


Fig. 4.8. Collection of larvae by jobarai method

3. Net Method

A net is placed after feeding the silkworms. Mature (ripe worms) crawl onto the net while others feed. The net is separated along with worms for mounting.

4. Branch Method

It is similar to net method where only mulberry shoots are used instead of nets. When worms crawl onto shoots are mounted.

5. Self – Mounting

First mature worms are picked by hand then a self-mountage frame is placed on the surface of silkworm beds. Ripe worms crawl onto the mountage frame, which is later hanged. This method of mounting is also called self-mounting as it makes use of the negative geotropic character of the matured silkworms, the tendency to climb up. When about 20% of larvae get matured, mountages like plastic collapsible mountages placed on the rearing bed. By this method labour can be saved.

4.5.3 Density of Mountage

The density varies according to the size and type of mountage (Table 4.1). The ripe worms ordinarily require an area which is the square of its body length for spinning its cocoon. Providing too much spacing during spinning is uneconomical and also not advisable due to additional mountages and labour are required which is of not economical. Further there is scope for wastage of silk for spinning the preliminary web.

Further, too much closer spacing is also not advisable since such practice may lead to production of more double cocoons. Scope for soiling and staining of the cocoons with excreta is very high. It also leads to poor ventilation which hampers the drying up of cocoons. Due to this, more of damp, stained and inferior cocoons are formed.

Number of mature larvae to be mounted on a mountage depends upon the type of mountage used. In Chandrike 40-50 larvae are mounted per square foot. In the case of rotary card board mountage only 90% of the capacity of the mountage is mounted, in bottle brush mountage 500 larvae are mounted per metre length and in plastic collapsible mountage 50 larvae are mounted per sq. ft. If the number of larvae mounted is more, defective cocoons such as soiled at cocoons, double cocoons etc. will be increased, making the cocoon quality poor and if the number is too small mounting become laborious and uneconomical.

Table 4.1. Density of mounting for different mountages

Sl.No.	Type of Mountage	Larval density
1	Bamboo chandrika	50 worms per 10 x 10 cm (1100 per chandrike)
2	Rotary mountage	1500 per mountage (40 mountages per 100 Dfls)
3	Plastic collapsible mountage	50 – 60 larvae / sq.ft.

4.6 Environmental Conditions

Mounting and spinning are to be carried with at most care to get good quality of cocoons. Ideal temperature of 24^{o} -25^{o}C and relative humidity between 60-70% are required. These conditions are important during the first 50 hrs, after mounting. Temperature of 24^{o} - 25^{o} C and relative humidity between 60-70% are required. Above the optimum environment *i.e*. temperature above 26^{o}c and humidity 70% affects the cocoon quality.

The environmental conditions such as temperature, humidity, light, air current etc. also plays a major role in providing good quality cocoons. The optimum temperature required for spinning cocoons is 24-25ºc. The temperature above the optimum makes the quality of cocoons poor and below increase pupation period. In order to maintain the health of the larvae and good reelability of cocoons the relative humidity of mounting room must be as low as possible. Humidity of 60-70% is considered ideal. This has to be checked by providing good ventilation.

4.7. Care during Mounting

Quality of cocoons mainly depends on the type of mountage and the care taken during mounting. If immature larvae are mounted, number of dead larvae in cocoons will be more, silk thread will be less. If immature and matured larvae are mounted together in the same mountage, soiled cocoons will be increased.

1. In the mounting hall old newspaper or mats are to be kept under the mounting frame and when urine and excreta falls on the paper it should be removed.

2. If the temperature rises beyond 22^o -23^{o}C the shell becomes very loose and folded with wrinkles and knots. It also changes the properties of sericin. This induces cohesion of silk filaments and causes difficulties in reeling.

3. Low temperature slows down the secretion of silk bave resulting in large size cocoons. Further it takes very long time for spinning.

4. Relative humidity (60-70%) induces good health, good reelability and quality cocoons. When it rises the larvae and pupae cease to death. Low humidity causes double layered cocoons, loose cocoons.

5. Air current speed should be less than one meter per second and fast or strong air current causes crowding of mature silkworms resulting in excessive number of double cocoons.

6. Mounting room requires moderate, even illumination. Strong light causes crowding of silkworms at one side and finally results in double cocoons or uneven thickness cocoons.

7. Complete darkness will slow down the spinning process resulting in low quality cocoons. So sufficient light should be ensured.
8. Ants crawling on to the mountages is to be prevented.
9. Spinning worms should not be disturbed.

4.8 Cocoon harvesting

The silkworm larva metamorphosis into pupa after spinning the cocoons for about 48 hours from the time they are mounted.

Generally pupation takes place on the 4th day of spinning. Thus the worms inside the cocoons will be still in the form of pre pupa, which has a delicate cuticular skin. Thus if the cocoons are handled before this stage, the skin may rupture and body fluid will ooze and stain the cocoons, making it unsuitable for reeling. Thus early harvesting of cocoons should be strictly avoided.

In course of time the pupal skin hardens and turns to dark brown. The cocoons are then harvested on the 5th day in summer and 6th day in cooler season. In the case of seed cocoons, they may be harvested on the 6th day. Harvesting must not be delayed beyond the above said period because it affects the reeling activity.

Before harvesting the cocoons, the mountages are held in a slanting position with the cocoon side downwards and given a gentle shake to dislodge the faecal material. The flimsy cocoons are taken out with forceps or chopsticks. Care must be taken not to rupture the cocoons as their body fluid or dead silkworms may stain good cocoons. The cocoons harvested are kept in thin layers in a tray or on a mat. After harvesting, the cocoons are first cleaned to remove pellets or debris sticking to the cocoons. Then they are sorted to separate bad cocoons.

Mounted silkworm can complete cocooning in about two days. It becomes pupa in another two days. At the beginning of pupation the skin of pupae is soft, fragile and liable to the wounded easily. If cocoons are harvested at this stage, the interior layer of cocoons shell is soiled which effect reelability. It takes 2-3 days after pupation for the skin to become harder. Hence, cocoons should be harvested only on the 6th day. Therefore, it is safe to do harvesting after hardening of the pupal skin, it is tested by shaking the cocoons gently. Cocoon harvesting method depends on the kind of mountage used. Before harvesting all diseased and unspun larvae should be removed, otherwise it can spoil the good cocoons.

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Fig. 4.9. Harvesting of cocoons from chandrike

Harvesting of cocoons from Rotary Mountage: Remove each of the ten cardboard mountage from the wooden frame after keeping vertically and remove the dead worms, thin cocoons etc. The good cocoons in the frame are pushed out one line after another by a cocoon pusher in the frame in the wooden frame for harvesting cocoons. Cardboard frames are then folded and bundled. If a treadle machine for pushing out cocoons from the cardboard mountage is used, it can be ten times faster than the hand pusher method and is worth using in a mass rearing (Fig. 4.10.).

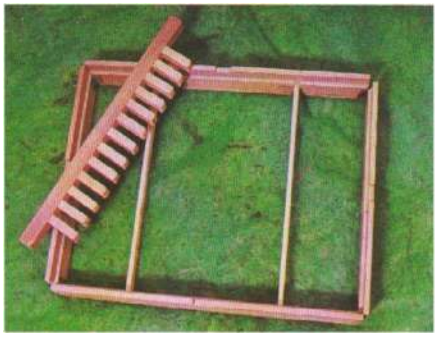


Fig. 4.10. Cocoon harvester and harvesting of cocoons from rotary mountages

Floss removal: It is necessary that floss covering the cocoons must be removed before marketing for getting a good price for cocoons for bivoltine. Deflossing is not required for multivoltine x bivoltine (cross breed) cocoons. Floss can be removed by hand if the cocoon quantity is small (Fig. 4.11). If quantity is more, de-flossing machine can be used (Fig. 4.12.) After cocoons are harvested, the cocooning frame can be exposed to sun for one or two days for disinfection and can be stored properly for next rearing.

Fig.4.11. Floss removal (manually)

Fig.4.12. Various machines for floss removal

Sorting of cocoons: After floss removal the defective cocoons (Fig. 4.13) such as double, printed, soiled, thin end, malformed, thin shelled, pierced and loose shell cocoons are sorted out. These cocoons are kept as a separate lot while marketing.

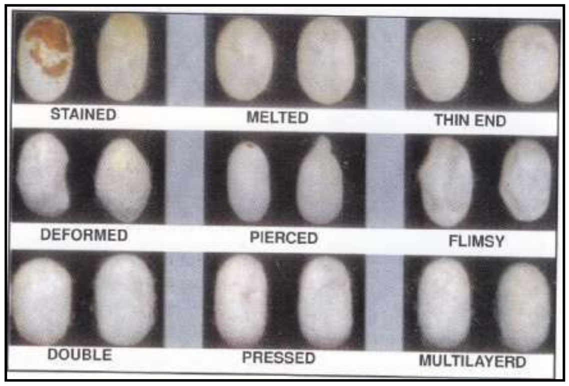


Fig. 4.13. Defective cocoons

4.9. Transport

The cocoons should be cleaned by removing floss, litter, leaf material etc. after harvesting (Fig.4.14). Double cocoons and flimsy cocoons are separated out and the cocoons are transported. The cocoons should be put into loosely woven cotton bags. They are loosely packed and transported in cooler hours of the day (*i.e.* morning or evening). If transported in larger bags, cocoons will be steamed or crushed. Strong vibration during transportation is harmful because cocoons might be crushed. While transporting cocoons are protected from direct sunlight and rain. It is also important that cocoon cost depends on the quality and are well protected from direct sunlight and humidity.

Fig. 4.14. Good Cocoons (CB & Bivoltine)

Cocoons are placed in heaps, samples are given for quality testing, based on which cost is decided. The cocoon quality is based on certain aspects like hatching percentage, ERR percentages of good and bad cocoons, shell ratio, denier, filament length. All these factors influence the cost of cocoons. If de-flossing of cocoons is done, reelers would pay a reasonable higher price for such lot of cocoons.

4.10. Byproducts of silkworm rearing and value addition

In India, area under mulberry during 2014 - 15 is around 2.19 lakh hectares producing 1,59,259 metric tons of cocoons with a raw silk productivity of 97.30 Kg/Ha. It is estimated that 164.86 lakh tons of byproduct in terms of rearing waste is available from the present mulberry growing area. Whereas pupa which is a major byproduct of reeling sector is about 1,11,481 tons available for proper value addition (Savithri *et al*., 2016).

If sericulture industry needs to be kept alive in all parts of India, wastes generated during all sericultural activities can very well be converted in to valuable products of industrial value. Value-added product simply means any product that helps to raise the value of the products or business or something can add to a product that enables to increase profit margin.

Realizing the scope of utilizing by-products of silk cocoons by applying appropriate methods is the immediate need to optimize returns. The by-products presently felt as wastes, can put to better use in generating the value-based products and thereby project the industry to a more profitable and economically viable. The cost of end product, the silk can be proportionately brought down by the combination of regulating the processing methods and converting the wastes as useful by-products. The optimal by-product utility concept can be highly useful to sericulture industry, which helps in alleviating the socio economic status of the rearers.

Sericulture activity involves 3 different activities

1. Moriculture, the cultivation of mulberry.
2. Rearing of silkworms.
3. Reeling of cocoons to produce raw silk

In each of these activities, number of by-products, popularly known as waste is generated & these by-products can be put to good use for value addition to the sericulture industry.

Classification of by-products: According to their generation, the by-products are classified as follows:

1. **By-products of moriculture**: Excess of pruned leaves can be used as feed for cattle, manure or mulches for the mulberry garden are as fuel. Excess of pruned branches could be used as a fuel and rejected plants can be used as raw material for paper pulp industry.

2. **By-products of silkworm rearing**: Silkworm litter, left over mulberry leaves, pierced cocoons, cut cocoons, floss, double cocoons, melted, flimsy, stained and urinated cocoons.

Uses of bi - products of silkworm rearing

1. **As compost**: Left over mulberry leaves & silkworm litter can be used as compost in order to increase the fertility & productivity of the soil. Moreover, it enhances the water holding capacity of the soil, Destroy harmful pathogen.
2. **As animal feed**: Rejected, dead & cast larval skin is good for poultry feed.
3. **Suturing material**: Silk gland from dead worms used as surgical suturing.
4. **Feed for biogas plant**: Silkworm litter along with cow dung could be used as raw material in the Biogas plant.
5. **Pharmaceutical industry**: Pharmaceutical & perfumery compounds are produced from silkworm litter in China. Used as the duo, healing agent & as medicine for stopping the bleeding of gums.

6. **Pierced cocoons as a by-product & their use in silk industry**: Pierced cocoons can be used for producing fabrics like bed sheets, chadder, lady scarves, curtains, table - cloth & caps. Even the cocoon shells could be used for preparation of handicrafts such as garlands, bouquets etc.

Thus by-product utilization hopefully should play a crucial role in the coming years to make the sericulture an economically viable proposition enabling it to withstand competition from other cash crops. The useful conversion of by-products through indigenously available processing techniques brings additional income which lead to socio economic up-liftment of rearers. The R&D institutions, Sericulture departments, policy makers should work towards popularize the concept of value addition and global marketing outlets for effective by-product utilization in today's competitive competition. The realization of value addition span, application of suitable technology and optimization of utilizing by-products of silkworm cocoons by all the stake holders is the integrated want of silk industry.

Summary

- *Mounting of silkworms on proper mountage is the final process in silkworm rearing and is the most laborious activity.*
- *Ripe or mature worms are identified by translucent and yellowish colour. These are picked in time for cocoon spinning. The spinning larvae are allowed to spin cocoons by placing on mountages.*
- *Worm passes out last excreta before it starts spinning. The worm first oozes a tiny drop of silk for anchoring and then draws a long filament by swinging the head continuously.*
- *Selection of suitable mountage and protection of spinning larvae for 3 – 4 days providing optimum environmental conditions has a profound influence on quality of cocoons.*
- *Spinning takes 2-3 days, to wrap itself into a compact shell.*

- *The inner most layer (gossamer layer) and outer most (floss) layers are not reelable.*
- *Temperature (22^o – 23^o C), humidity (60-70%), good air current and ventilation are required.*
- *Cocoons are harvested after 5-6 days of mounting.*
- *Cocoons are transported in cooler hours of the day by packing in loosely woven bags/ baskets.*
- *Cocoon assessment is calculated based on shell ratio, floss percentage, denier, filament length etc., for price fixation.*
- *The Sericulture industry needs to be kept alive in all parts of India, wastes generated during all sericultural activities could be very well converted in to valuable products of industrial value.*
- *The optimal by-product utility concept can be highly useful to sericulture industry, which helps in elevating the socio economic status of the rural poor rearers.*

Short Answer Type Questions

1. How do you identify ripen / spinning worms?
2. Define mounting.
3. Mention the reasons for defective cocoon formation.
4. Define spinning.
5. Define floss.
6. What is palade layer?
7. What are the temperature and humidity levels required during spinning?
8. Define cocoon harvesting.
9. Define sorting of cocoons.
10. What are the factors that influence price fixation?
11. Classification of byproducts in sericulture

Long Answer Type Questions

1. Write notes on structure of silk gland with neat labeled diagram.
2. Explain about mounting and various devices for mounting.
3. Write notes on requirements of spinning.
4. Detail about types of mountages along with their merits and demerits.
5. Write short notes on

   (a). Transport of cocoons (b) Ripen worms
   (c) Cocoons sorting (d) value addition

Student Practice Questions

1. Identify the ripen worms during your visits to farmers field.
2. Make models of different types mountages by using bamboo, card board sheets.
3. Make models of decorative items like flower bouquets by using waste cocoons for value addition to the industry.
4. Discuss with your lecturer and explore various possible ways for value addition to the sericulture industry.

UNIT 5

Effective Rate of Rearing (ERR)

Structure

Learning Objectives

After studying this chapter students will be able to understand,

- The formula of ERR and calculate the ERR by number and weight.
- Factors that influence ERR
- The formula of LCR and its calculation
- Leaf cocoon ratio

5.1 Introduction

Sericulture is the science that deals with the production of silk by rearing of silkworm. Silkworm happens to be one of the most important domesticated insects, which produces luxuriant silk thread in the form of cocoon by consuming mulberry leaves during larval period. The success in silkworm rearing is greatly influenced by environmental conditions. The biological as well as Effective Rate of Rearing (ERR) are greatly influenced by breeds / hybrids, quality of mulberry leaf, environmental conditions, rearing season, rearing management which includes disinfection and disease management, technological interventions and knowledge of the silkworm rearer. The term ‘ERR’ indicates, how effectively the rearer has carried out rearing to harvest cocoons.

Over the last five decades, though there is a tremendous impact of R & D leading to increase in silk production in India, much more needs to be done in the coming years. Tropicalisation of sericulture technology in general and bivoltines in particular suiting to Indian conditions coupled with high yielding mulberry varieties, bio-fertilizers and bio-agents for eco-friendly practices, productive silkworm breeds that produce international quality silk, entrepreneur oriented chawki rearing centers for assured chawki crops, mechanization of several processes to reduce drudgery and save on time and labour, are just a few of the areas that could find quick acceptance by the stakeholders in the field which has revolutionized the Indian Sericulture industry in recent years. Further the progresses made in various approaches has made to increase ERR among the farmers.

Silkworm rearing technologies plays a vital role in the production of quality silk which has a combined impact of nutritional value of mulberry, environment and adoption of rearing technology. The potential of silkworm hybrids and nutritional quality of mulberry though plays a major role, the interaction of these inputs into a rearing technological package is more critical and challenging to harness the desired productivity level. These technologies have direct influence on the ERR and productivity in silkworm rearing.

The seasonal differences in the environmental components considerably effect on the various parameters such as ERR, Cocoon weight, shell weight and shell ratio. So, the variations in the environmental conditions during the silkworm rearing need to be managed to ensure success in general and for better ERR in the silkworm rearing.

Silkworm rearing is to be carried systematically for harvesting better cocoon crops. Rearing activities such as incubation, brushing, feeding, leaf quality, bed cleaning, and spacing are important which reflect on the quality and quantity of cocoons. Reducing of missing larvae during bed cleaning, reducing diseases and proper maintenance of rearing activities directly influences the ERR and yield parameters. Above all, maintenance of environmental conditions especially temperature and humidity are vital for growth and health of silkworms. Any deviation may hamper the health of the silkworms which leads to disease and finally results in crop loss. Quality cocoons are the final product in silkworm rearing to get cash returns.

Therefore it is necessary to understand about the effective rate of rearing (ERR) to know how efficiently the rearing is being carried and to estimate the crop results. The calculation of ERR also helps the farmer to understand mistakes done to avoid in the rearing activity. In this chapter calculation of ERR by various methods utilizing weight and number of cocoons are discussed along with calculation of good and defective cocoon percentage for the benefit of entrepreneur. It is also discussed on various points that are influencing the ERR in specific and crop success in particular.

1. Role of temperature and humidity:

As the silkworms are cold –blooded animals, the temperature will have a direct effect on various physiological activities. In general the early instar larvae are resistant to high temperature which also helps in improving ERR and cocoon characters. The temperature has a direct correlation with the growth of silkworms and wide fluctuation of temperature is harmful to the development of silkworms. The optimum temperature for normal growth of silkworms is between 24° - 30℃. If the Temperature is below 20℃ all the physiological activities are retarded, especially in early instars, as a result worms become too weak and are susceptible to various diseases.

Humidity plays a vital role in silkworm rearing and its role is both direct and indirect. The combined effect of both temperature and humidity largely determines the satisfactory growth of the silkworm and production of good quality cocoons. It directly influences the physiological functions of the silkworm. It also indirectly influences the rate of driage of leaves in the silkworm rearing beds. Under dry conditions especially winter and summer the leaves dry very fast and consumption by the larvae gets effected which results in wastage of leaf in the rearing bed. Retarded growth of young larvae makes them weak and susceptible to diseases. Like temperature, humidity also fluctuates widely not only from season to season but also within the day itself. Therefore, it is necessary to regulate it for achieving high ERR which in turn influences on the crop yield.

2. **Role of breeds / hybrids**:

As discussed in earlier chapters, the breed / hybrid also plays a major role in obtaining higher yields in silkworm rearing. Variations of the ingesta and digesta values among the different breeds and same breed in different seasons have been proved. Various research findings have proved that the effect of temperature on leaf silk conversion in silkworm reported that low temperature throughout the rearing period favored higher silk conversion with better ERR among bivoltine breeds.

Further, breeds or hybrids with disease resistance have much scope for crop success and better ERR. Due to concerted efforts of Research and Development in sericulture made the availability of productive silkworm hybrids. The awareness on recent technologies by the farmers and tropicalization of bivoltine sericulture made to produce quality cocoons with international grade of silk. Later with the introduction of double hybrids, the bivoltine cocoon production has brought up the better ERR.

3. **Rearing management:**

The care taken and management during silkworm rearing has direct impact on the ERR and cocoon yield. As discussed in the earlier chapters, right from brushing to cocoon spinning, required environmental conditions needs to be provided. The silkworms are to be fed with quality mulberry leaf based on the stage of the silkworm. Hygiene during silkworm rearing also needs to be maintained. During rearing, missing larval percentage needs to be minimized by proper care during bed cleaning. All the possible steps are taken for disinfection and for disease management in silkworm rearing.

4. **Knowledge level of farmer:**

The knowledge level of the silkworm rearer (farmer) in silkworm rearing plays a major role in ensuring crop success and better ERR. If the farmer is trained and experienced in silkworm rearing there is a scope to harvest good crops with better yield. However the ability of the farmer to manage various critical issues during silkworm rearing has a direct scope in influencing the farmers success and the ERR.

5. **Adoption of technologies:**

The efforts made by the Scientists, resulted in the development of field oriented various technologies which are eco and user friendly and made it possible to rear silkworms on more scientific manner leading to crop success with better ERR.

Effective rate of rearing

Earlier farmers used to brush sheet eggs where there was lot of variability in fecundity. The egg and larval number brushed and to the cocoons harvested is converted in percentage to calculate ERR. At present, the fixed number of eggs is available in the form of loose eggs for brushing. Hence, to evaluate the ERR of a breed /

hybrid/batch, yield per 10000 larvae by number and yield per 10000 larvae by weight are calculated.

Effective rate of rearing (ERR) is the ratio of total number of cocoons formed to the total number of silkworms brushed. Effective rate of rearing (ERR) indicates the survivability of silkworm during the silkworm crop. Generally among the cocoons harvested, the cocoons could be sorted such as good cocoons, double cocoons, melt cocoons and flimsy cocoons. All these cocoons except melt cocoons are taken into consideration for calculation of ERR.

ERR by number (Yield per 10000 larvae by number) =

$$\frac{\text{Total number of good cocoons harvested}}{\text{Total number of larvae retained after } 3^{rd} \text{ moult}} \times 10{,}000$$

ERR by weight (Yield per 10000 larvae by weight) =

$$\frac{\text{Weight of good cocoons harvested}}{\text{Total no. of larvae retained after } 3^{rd} \text{ moult}} \times 10{,}000$$

ERR can be calculated for 10,000 larvae or for 100 larvae as well. When ERR is calculated for 10000 larvae, it is expressed in terms of number or weight accordingly. Whereas, when it is calculated for 100 larvae it is expressed in percentage.

At present bivoltine eggs are being distributed in the form of loose eggs i.e. a box contains approximately 30000 eggs per 50 Dfls. In such cases ERR is calculated per 10000 larvae.

5.2 Calculation of ERR by Weight

ERR is defined as the ratio between the weight of cocoons produced and the total number of larvae brushed or retained at a certain instar.

Effective rate of rearing is calculated on the basis of weight and number of cocoons.

ERR by number =

$$\frac{\text{Total number of cocoons harvested}}{\text{Total number of larvae brushed}} \times 10{,}000$$

ERR by weight =

$$\frac{\text{Weight of cocoons harvested in kg}}{\text{Total number of larvae brushed}} \times 10{,}000$$

Now let us calculate ERR (in both methods) on the following values.

5.2.1. Exemplary Problem

The total number of larvae brushed is 1610 and the details of cocoon harvested are as follows

Sl. No.	Type of cocoons	Number	Weight (kg)
1.	Good Cocoons	1413	2.020
2.	Flimsy	36	0.050
3.	Double cocoons	42	0.055
	Total	**1491**	**2.125**

SOLUTION

Total No. of larvae brushed = 1610

Total No. of cocoons harvested = 1491

Total yield (kgs) = 2.125 kgs

ERR by number =

$$\frac{\text{Total number of cocoons harvested}}{\text{Total number of larvae brushed}} \times 10000$$

$$= \frac{1491}{1610} \times 10000 = 9260$$

It means for every 10,000 Larvae brushed, 9260 cocoons are harvested.

ERR by weight =

$$\frac{\text{Weight of cocoons harvested in kg}}{\text{Total number of larvae brushed}} \times 10000$$

$$= \frac{2.125}{1610} \times 10000 = 13.199 \text{ kg}$$

It means for every 10,000 larvae brushed, 13.199 kgs of cocoons are harvested.

5.2.2 Model Problem

Calculate yield (Kg)/100 DFL's on the basis of the following data.

E.R.R. = 80; Number of worms in 3rd instar per Dfl is 300.

Solution

ERR by number (%)

$$= \frac{\text{No.of cocoons harvested}}{\text{No. of larva in 3rd instar}} \times 100$$

Number of cocoon harvested per Dfl

$$= \frac{\text{Number of larvae in } 3^{rd} \text{ instar}}{100} \times \text{ERR}$$

$$= \frac{300}{100} \times 80 = 240$$

For 100 DFLs = 240 x 100 = 24,000 cocoons

Weight of single cocoon = 1.8 grams

Weight of 240 cocoons = 240 x 1.8 = 432 grams.

Yield for 100 DFL's =

Weight of cocoons harvested from one DFL x 100

432 grams x 100 = 43.200 Kg.

5.2.3 Model Problem

Calculate number of cocoons harvested if E.R.R. % is 90

Number of worms in 3rd instar per Dfl is 350.

Solution

ERR by number (%)

$$= \frac{\text{Number of cocoons harvested}}{\text{Number of larva brushed}} \times 100$$

Number of cocoon harvested / Dfl

$$= \frac{\text{Number of larvae in } 3^{rd} \text{ instar}}{100} \times \text{ERR}$$

$$= \frac{350}{100} \times 90 = 315$$

For 100 DFLs = 315 x 100 = 31,500 cocoons

Weight of single cocoons= 2.0 grams

Weight of 315 cocoons= 315 x 2.0 = 630 grams.

For 100 DFL = 630 grams x 100 = 63,000 gms.

= 63 kgs / 100 Dfls

At present, as the fixed number of eggs are available in the form of loose eggs that are being brushed or distributed. So to evaluate the ERR of a breed / hybrid/batch, yield per 10000 larvae by number and yield per 10000 larvae by weight are calculated and practiced, which is as follows;

ERR by number =

$$\frac{\text{Total number of good cocoons harvested}}{\text{Total number of larvae retained after } 3^{rd} \text{ moult}} \times 10{,}000$$

ERR by weight =

$$\frac{\text{Weight of good cocoons harvested in kg}}{\text{Total no. of larvae retained after } 3^{rd} \text{ moult}} \times 10{,}000$$

Problem: In a given batch 280 cocoons are harvested out of 300 cocoons retained and the weight of cocoons is 580 grams. Calculate the yield per 10000 larvae by number and weight separately.

Number of worms retained	= 300
Number of cocoons harvested	= 280
Weight of cocoons harvested	= 580 grams

ERR by number =

$$\frac{\text{Total number of cocoons harvested}}{\text{Total number of larvae retained after 3}^{rd}\text{ moult}} \times 10{,}000$$

$$= \frac{280}{300} \times 10000$$

= 9333 of cocoon yield per 10000 larvae

ERR by weight =

$$\frac{\text{Weight of good cocoons harvested in kg}}{\text{Total no. of larvae retained after 4}^{th}\text{ moult}} \times 10{,}000$$

$$= \frac{580}{300} \times 10000$$

= 19.333 kgs of cocoon yield per 10000 larvae by weight

During silkworm rearing, few cocoons are produced which are unreelable due to genetic character, disease occurrence, improper mounting, harvesting and transportation etc. For calculation of ERR, other than melt cocoons, all other cocoons are considered and after cocoon harvesting various cocoons are sorted out.

Cocoon harvesting

Silkworm completes cocooning in about two days after mounting and in another two days it metamorphosis to pupa. At the beginning of pupation the skin of pupa is soft and gets wounded easily, if cocoons are harvested at this stage the inside of cocoon shell is soiled and affects the reelability. After harvesting and floss removal, the defective cocoons are assorted into,

1) Double cocoons	2) Pierced cocoons
3) Cocoon frame printed cocoons	4) Soiled cocoons
5) Thin end cocoons	6) Deformed cocoons
7) Thin shell cocoons	8) Loose shell cocoons

These unreelable or defective cocoons are formed due to certain reasons which are described in detail.

1) **Double cocoons:** A cocoon jointly formed by 2 or more worms in called double cocoon. These cocoons are large and thick and cannot be reeled. Double cocoons are used to produce dupion silk. The occurrence of double cocoons depends on kind of mountages used, quantity of worms mounted and also the silkworm variety.

2) **Pierced cocoons:** This defect is mainly due to silkworm variety or due to the penetration of cocoon by maggot of uzifly.

3) **Cocoon frame printed cocoons**: While cocooning a part of cocoon surface adhered to the cocooning frame make a print on cocoon. Even if it is small raw silk cannot be reeled from such cocoons. This problem comes when the material for mountage is too hard or cocooning space is too small.

4) **Soiled cocoons**: Cocoons which are soiled by urination or diseased larvae cannot be reeled well. This occurs due to the kind of mountage and high density of worms in the mountage. Sometimes the worms die after spinning silk or just after pupation and soil the inner layer of the cocoon shell. Thus one should be careful during mounting and handling of cocoons.

5) Thin end cocoons: One end or both ends of a cocoon become very thin and not suitable for reeling. It is often due to genetic character or high temperature during incubation, malnutrition during rearing or strong wind under humid condition in the mounting room.

6) **Deformed cocoons:** A cocoon which is partly swollen or deformed in general cannot be reeled. It is formed when irregular space exist in the cocooning frame or when larvae are not healthy

7) **Thin shell cocoon:** Thin shell occurs when the crop is generally bad due to malnutrition or disease.

8) **Loose shell cocoons:** Cocoon shell is formed loosely as in multivoltine cocoons due to silkworm race and high temperature during cocooning.

Percentage of such defective cocoons can be limited to 5% or less if mounting is done properly. But if care is not taken during mounting, the percentage of such cocoons can go as high as 30%. These defective cocoons reduce the cocoon price.

5.4 Leaf Cocoon Ratio:

It indicates that, the ratio of mulberry leaf mass to cocoon output. It is a ratio indicating to produce one kg of cocoon, how much quantity of mulberry leaf is required. It is a racial / genetically influenced character. The leaf cocoon ratio is a measure to identify the efficiency levels in rearing. To derive the yield of one kilogram of cocoons, the leaf used should be around 30 kgs. Anything less than this indicates effective use of the leaf and anything more than this level indicates less efficient or inefficient use of the leaf.

If the ratio is lower, there is a scope to rear more number of silkworms, which inturn fetches higher returns to the farmers. Generally 1,500 – 1,800 kg leaf consumption leads to 55 – 65 kg cocoon production. Therefore the Leaf : Cocoon ratio will range from 1: 25 to 1 : 28. During the rearing period, the quantity of leaf utilized by larvae to harvest one kilogram of cocoon was recorded as leaf : cocoon ratio by using the following formulae

Leaf : Cocoon Ratio =

$$= \frac{\text{Quantity of leaf consumed}}{\text{Actual weight of cocoons harvested}}$$

Under shoot rearing method, since the leaves are attached to the shoots, the quality of leaves is maintained for a longer period which facilitates effective feeding and reduces the leaf cocoon ratio significantly.

Example: A farmer reared 100 Dfls of silkworms with 1500 kgs of leaf and harvested 60 kgs of cocoon yield. Find out the Leaf : cocoon ratio.

Number of kgs of cocoons harvested = 60 kg
Quantity of leaf consumed = 1500 kgs

Leaf: Cocoon Ratio =

$$\frac{\text{Quantity of leaf consumed}}{\text{Actual weight of cocoons harvested}}$$

Leaf : Cocoon ratio = 1500 / 60 = 25

It means to produce one kg of cocoons, 25 kgs of mulberry leaf is consumed or used.

Summary

- Calculation of ERR helps to know the rearers efficiency of rearing.
- Rearing activity reflects on cocoons quality and quantity. Cocoons are the final produce to get cash returns.
- ERR is the ratio between the weight or number of cocoons produced and number of larvae in 4^{th} instar.
- ERR is calculated based on larval number and weight of the cocoons.

- Calculation of percentage of good and defective cocoons also gives an idea on the performance of rearing activity.
- The leaf cocoon ratio is derived based on how much quantity of mulberry leaf is consumed to produce one kilogram of cocoons.

Short Answer Type Questions

1. Define ERR.
2. Write the principles to calculate ERR.
3. Define the principle to calculate Leaf cocoon ratio.

Long Answer Type Questions

1. Write in details about the factors that influences ERR?
2. What is leaf cocoon ratio and how it is helpful to silkworm rearer?

UNIT 6

Bivoltine Rearing Technology

Structure

Learning Objectives

After studying this unit, students will be able to understand,

- The importance of bivoltine rearing
- The importance of Bivoltine races and its rearing
- The Rearing aspects
- Aspects for bivoltine silkworm rearing
- Distinguish the improved and modern techniques in silkworm rearing.

6.1 Introduction

Indian silk industry has registered a phenomenal growth over the years and presently is accounting approximately for more than 18% of the global silk production. India has emerged today as the second largest producer of mulberry raw silk besides producing all the varieties of commercially exploited silks of the world. Such an achievement was made possible solely due to significant breakthrough made in Research and Development in tropical sericulture.

Bottlenecks in the field of bivoltine cocoon production have been identified and addressed to a great extent. The new breeds/hybrids, which have been released in the field are high yielding and hold promise for producing international grade silk. In fact, the "new era" in production of bivoltine has begun with a promise of higher gain for both the primary producers and reelers alike. Needless to mention that, still more is to be done in achieving the target of enlarging the production base of bivoltine in the larger interest of sericulture industry in the country and also to compete in the international market. The farmers have adopted bivoltine single hybrid and subsequently migrated to use double hybrids at large scale for commercial rearing. The progressive seed farmers who have sound knowledge of rearing technology with irrigated mulberry garden and dedicated rearing house have realized the potentiality and benefit of raising bivoltines. Young age silkworm rearing has an important role to play in the success of both seed and commercial cocoon crops of bivoltines.

The bivoltine silkworms produce cocoons with high raw silk recovery and bivoltine silk excels in quality and International standards originating from temperate countries. These breeds have been evolved in luxuriant climate and nutrition. If these are to be raised under tropical conditions one has to provide optimum conditions to realize the full competence of the breeds/hybrids. Keeping in view of the optimum rearing temperature requirements for bivoltines under tropical condition the cooler months of the year *i.e.,* August-February are ideally suited in general for bivoltine rearings in South India when temperature is moderate with less fluctuations. The success of bivoltine crops depends primarily on the following.

- Farmers with a separate rearing house and if there is no separate rearing house a separate room provided with windows and ventilation
- Conducting of systematic disinfection before and after each crop.
- Having own mulberry garden with irrigation facility for raising quality mulberry leaf for young and late age worms.

- Capable of applying adequate quantity of manure (FYM) and fertilizer.
- Having adequate rearing equipment
- Having knowledge on the use of disinfectants and maintaining hygiene in the rearing house during rearing.

The pace of bivoltine silk production in India picked up momentum during 2001-2002. Prior to implementation of JICA project during early 90's the issues were non availability of silkworm breeds suitable for tropical conditions of India, appropriate bivoltine sericulture technology coupled with egg production technology, inadequate extension services which were serious barriers in promotion of bivoltine development. The above issues have been addressed to a greater extent under JICA project followed by IVLP (Institute Village Linkage Programme) and CDP (Cluster Development Programmes) programmes.

The contributions made by the premier sericulture research institutes of the country as well state owned Research institutes of Sericulture towards silk industry are remarkable and praiseworthy. The Scientists have been developing suitable package of practices for the tropical conditions. Though India stands second in the world silk production, next only to China, the production of bivoltine silk in India is less and the silk produced is not of international grade and is not suited for power looms. Hence, a large quantity of Chinese silk is imported and utilized due to the shortage of quality silk in the country. To overcome this problem, an Indo-Japanese collaboration project on Bivoltine Sericulture technology Development was initiated in India.

Initially during the first phase of JICA, new productive bivoltine silkworm breeds, technology for rearing and controlling diseases along with improved mulberry cultivation practices and mulberry varieties were developed. These technologies were finetuned under field condition with selected farmers in association with respective state departments of Sericulture during the first two years of JICA second phase. As a result, it was made possible to demonstrate that bivoltine crops can be successfully and reared meticulously in the field with a stabilized yield and international quality of silk of 2A-3A grade can be produced. To achieve success and for sustainable bivoltine sericulture focus should be given on top priority to the following aspects in a more scientific manner.

- Rearing of parental breeds for quality seed cocoon production
- Growing robust young age larvae in a scientific manner
- Reduction of defective percentage in seed and commercial cocoon production
- Improvement of egg yield
- Improvement of cocoon weight thereby increase in cocoon yield
- Improving the practice of hygiene especially during the final instar of silkworm rearing.

Bivoltine sericulture excels in quality and productivity. Success and development of bivoltine sericulture largely depends on practicing the specialized packages, skillful management in different facets such as disinfection, maintenance of hygienic conditions, feeding of sufficient quantity of quality mulberry leaf, quality silkworm seed and disease management. However various guidelines are followed at various aspects to harvest successful bivoltine crops. The important areas which are to be followed in each stage have been discussed in nutshell manner in this chapter.

6.2. Bivoltine breeds/hybrids

Early history of Indian silkworm breeds: Sericulture is introduced as commercial venture way back in late 17th century and thereafter, silkworm breeding was initiated during 1920's. Basically polyvoltine rearing prevailed up to 1950's and indigenous polyvoltine breeds like Pure Mysore and C. Nichi in South India, Nistari in West Bengal, Sarupat and Moria in the North East. Though, these breeds were very well adapted and popular in respective regions, their productivity and quality of silk was strikingly low with very high renditta. Subsequently multivoltine x multivoltine and multi x bivoltine hybrids were exploited commercially in sericulture industry. By utilizing these breeds / hybrids could not result in quality silk production. To meet the international demand and to earn foreign exchange, the need was felt to rear bivoltines in Tropical country like India.

Bivoltine breeds/hybrids of the past: During 1970's, efforts were made to develop bivoltine breeds by extraction of lines from the single and double hybrids of exotic origin. The bivoltines were used only as male components for cross breed preparation and PM x NB4D2 became very popular in South and Nistari x NB4D2 in West Bengal.

New productive bivoltine breeds/hybrids: The bivoltine breeds developed earlier could not be popularized as the shell ratio realized at the commercial level was around 18-19% only which is slightly higher than cross breeds. Hence R & D efforts were made to evolve hybrids and as a result, the hybrid namely, CSR2 x CSR4 is identified as highly productive single hybrid.

Characteristics of CSR2 (Fig.6.1)

- Productive breed with better post-cocoon parameters
- Plain larvae with bluish white body colour
- Bright white oval shaped cocoons with fine to medium grains
- Cocoon shell ratio : 24-26%
- Raw silk percentage : 19-20 %
- Fiber quality : 2A ~ 4A grade

CSR2

Fig.6.1. Larvae and cocoons of CSR2

Characteristics of CSR4 (Fig.6.2)

- Plain larvae with bluish white body colour
- Bright white dumb-bell shaped cocoons with fine to medium grains
- Cocoon shell ratio : 22-23%
- Raw silk percentage : 17-18 %
- Fibre quality : 2A ~ 4A grade

CSR4

Fig.6.2. Larvae and cocoons of CSR4

At present, the bivoltine single hybrid (CSR2 x CSR4) is being exploited commercially on a large scale at farmers level during favourable months (September - February). These hybrids recorded an average cocoon yield of 65kg/100dfls. Both the hybrids and their reciprocals recorded renditta on an average of 6.00 and produced quality silk of 2A to 4A grade.

CSR2 x CSR4

Fig. 6.3. Larvae and cocoons of CSR2 x CSR4

Characteristics of CSR2 x CSR4 (Fig.6.3)

- Productive hybrid and easy to handle by farmers under hygienic conditions
- Plain larvae with bluish white body colour
- Hybrids with high cocoons shell ratio (22-24%) and raw silk recovery (19-20%)
- Better fibre quality (2A~4A)
- Rearing during favourable months in southern states
- Cocoons are bright white with intermediate shape and medium grains
- Better return for cocoon producer and reeler
- Renditta : 5.6 - 6.1

Double Hybrid production

The production of bivoltine single hybrid eggs at grainages faced frequent problems due to poor quality cocoons produced by Pl seed farmers. Keeping this in view, for easy rearing of foundation crosses (FCs) and also to increase the egg recovery at grainages, double hybrids were developed. Double hybrids are known to have more genetic plasticity to buffer against adverse climatic condition and can be reared throughout the year and at present most of the farmers are rearing the bivoltine double hybrid (CSR6 x CSR26) x (CSR2 x CSR27). This double hybrid is having cocoon weight of 2.15 g, shell weight of 0.510 g shell percentage of 23.7 %, raw silk percentage of 19.97%, filament length of 1180 m, reelability percentage of 86 %, neatness of 95 p and has recorded cocoon yield of 68.75 kg / 100 dfls in the field.

R & D efforts of Andhra Pradesh State Sericulture Research and Development Institute (APSSRDI):

Similarly efforts were also made at APSSRDI and developed bivoltine hybrids such as APS9 x APS8 (Kalpatharuvu), APS5 x APS4 (Hemavathi), APS45 x APS12 and Double hybrids suitable to climatic conditions of Andhra Pradesh. These hybrids were successfully exploited commercially in the state of Andhra Pradesh (Table 6.1).

Table 6.1. Characteristics of Bivoltine hybrids developed at APSSRDI

Sl. No.	Character	APS5 x APS4 (Hemavathi)	APS9 x APS8 (Kalpatharuvu)
1	Larval duration (Days)	22:00 – 24:00	22:00 – 23:00
2	Cocoon weight (g)	1.70 – 1.80	1.75 – 1.80
3	Shell weight (g)	0.340 – 0.380	0.350 – 0.390
4	Cocoons shell ratio	20.00 – 22.00	21.00 – 22.00
5	Raw silk percentage	17 - 18	17 - 18
6	Renditta (Kg)	6.8 – 7.0	6.5 – 7.0
7	Fiber quality	3A	3A

Rearing aspects: Various factors influence the success of bivoltine silkworm rearing and the details of which are as follows.

6.3.1. Separate rearing house

The rearing of the mulberry silkworms is indoor and fully domesticated. The rearing house should be rationally designed in order to keep the micro-climatic and environmental conditions for rapid and healthy growth of the silkworms. Hence the rearing house should have facilities for creation and maintenance of the optimal environmental conditions inside the silkworm rearing house. The rearing house should also provide sufficient space and healthy environment for the workers attending the silkworm rearing. To succeed in the rearing of bivoltine hybrids, utmost care has to be taken in each and every aspect right from selection and procurement of layings or chawki silkworms. The various steps that are to be followed have to be ensured for the success of bivoltine silkworm rearing which has been dealt in this chapter. Further during the construction of rearing house, particularly for the rearing of bivoltine silkworm hybrids, the following aspects have to be taken care **(Fig.6.4 & Fig.6.5)**.

- Should have adequate number of windows, ensuring free cross ventilation.
- Construct rearing house of 50 feet x 20 feet x10 feet size on an elevated and shady place.
- Provide 3 feet verandah surrounding the rearing house.
- Provide sufficient windows and ventilators for free circulation of air inside the rearing house.
- Cover the windows and ventilators with nylon net to restrict the entry of uzi fly.
- Ensure air tight condition to facilitate effective disinfection of the room/house as and when required.
- Constructed nearer to the mulberry garden that reduces the excess expenditure for man power, transportation and provides better management.

Fig. 6.4. Separate rearing house for silkworm rearing

Fig.6.5. Rearing house near mulberry garden

6.3.2. Disinfection and Hygiene during silkworm rearing

Bivoltine silkworms are more susceptible to diseases compared to cross breed silkworms. Prevention is the best option available for avoiding the loss due to diseases in silkworm rearing. Proper disinfection (Fig.6.6) of rearing house, its surroundings and appliances and practice of hygienic measures are the important integral activities in silkworm rearing to prevent the diseases. Like other insects, silkworms are prone to diseases and pest. Therefore, it is essential to control the diseases for successful crop harvest.

Fig. 6.6. Disinfection of rearing house, surroundings and rearing trays

Diseased silkworms releases pathogens into the rearing environment and form the source of infection leading to spread of the diseases. These pathogens are highly stable and persist for longer period in silkworm rearing environment. Destruction of disease causing pathogens is called disinfection. It can be attained by various methods but the most effective method is chemical method using chemicals as disinfectants. Disinfection of rearing house, rearing appliances, silkworm rearing bed and silkworm body surface and the practice of hygiene are the most essential activities for successful harvest of cocoon crop.

To prevent and/or control silkworm diseases, more attention should be paid to the disinfection. The most commonly used disinfectants in earlier days were formalin and bleaching powder. At present various disinfectants are available such as Sericol, Agni, Asthra, Sanitech, Decol etc. which are eco and user friendly in nature. During disinfection programme (**Table 6.2**.), the following needs to be considered.

- Disinfect preferably at room temperature (24-25°C). The efficacy decreases when the temperature is less than 20°C.
- Soon after the completion of each rearing, wash and disinfect thoroughly the rearing equipment, rearing house, incubation room, leaf preservation room and mounting hall with 1% bleaching powder in 0.3% slaked lime.
- The appliances need to be sundried thoroughly.
- Disinfect the rearing trays by dipping them into 2% bleaching powder in 0.3% slaked lime + 0.2% detergent solution or 0.3% slaked lime + 0.2% detergent solution first and then after 30 minutes with 3% formalin by enclosing the trays, mountages etc., by a vinyl sheet.
- Power sprayer needs to be used for effective disinfection of rearing house.

Table 6.2. Schedule of cleaning activities before commencing rearing

Day	Details of Activity
Immediately after the completion of rearing	• Burning of diseased larvae and flimsy cocoons. • Disinfection of mountages. • 1st disinfection of rearing house and appliances
Five days before subsequent brushing	• Cleaning and washing • Sun drying of appliances
Four days before subsequent brushing	• Optional disinfection of rearing house with 0.3% slaked lime solution
Three days before subsequent brushing	• 2nd disinfection of rearing house and appliances with recommended disinfectant
Two days before brushing	• Dusting disinfectant (5% Bleaching powder in slaked lime) in front of rearing house and to the passage • Open the window of rearing house for ventilation
One day before brushing	• Preparation for brushing.

Practices of hygiene during rearing

Disinfection of rearing house, its surrounding and appliances aims at destruction of primary and secondary sources of infection before the initiation of silkworm rearing. However, pathogens can gain entry into rearing house through the rearer and from diseased silkworms. The disease may spread by unhygienic handling of silkworms and bed refuse. Hygienic measures (Fig.6.7 & 6.8) are meant for prevention of these secondary sources gaining entry into the rearing house and also disinfection of them during rearing.

- Wash hands and feet with disinfectant at the time of entry into rearing house and as well as after feeding. Also wash hands with disinfectant after picking diseased larvae and after bed cleaning.
- Carefully collect diseased worms from the rearing bed in a basin having disinfectant and destroy them by burning or burying.
- Collect silkworm bed refuse into litter basket/vinyl sheet meant for it. Never allow the bed refuse to fall on the floor of rearing house.
- Store mulberry leaves in a separate room having separate room.

- Dust slaked lime powder on worms settled for moult.

- Disinfect rearing bed by dusting bed disinfectants before resumption of feeding after every moult and on final instar as recommended *i.e.* @ 3g/sq ft (2nd and 3rd instar) and 5g/sq ft (4th and 5th instar).

Fig.6.7. Personal hygiene during silkworm rearing

Fig. 6.8. Disposal method of diseased larvae

6.3.3. Incubation and Brushing:

Incubation is the process of facilitating the growth and development of the embryo inside the egg till hatching. It involves providing the required ambience to the egg which includes the required temperature (25°C), relative humidity (80%), light (16 hrs.) and aeration. The modern way of incubating the eggs is to spread them in trays in the incubator having facilities to control the temperature, humidity and light hours. The egg sheets (Fig.6.9) or loose eggs spread in the rearing tray on a paraffin paper, cover them with another tray and then with moist cloth. In summer, when the temperature is much higher, the eggs have to be incubated in earthen pots which are kept in wet sand and covered with wet cloth. Wet foam strips may be used whenever Relative humidity falls below 70%. Normally 10 days are required from egg laying to hatching, which however may vary from 9 to 11 days according to temperature and humidity.

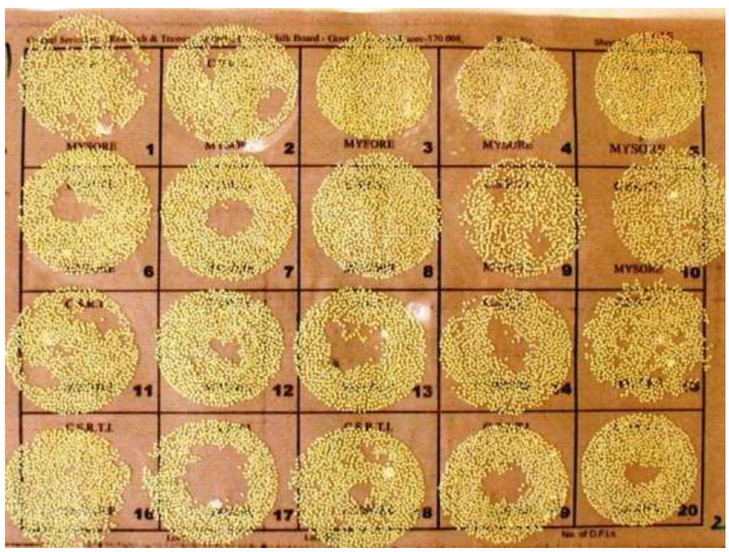


Fig. 6.9. Quality silkworm layings

1. Transportation of Silkworm eggs

Now a days, the farmers are rearing bivoltine chawki silkworms brought from Chawki Rearing Centers (CRC's), even technically also suggesting for the same. If at all farmer wish to brush by procuring layings from grainages, proper care has to be taken during transportation of silkworm eggs and the following are to be followed.

- Ideal time for transportation is within 4 days of embryo development.
- It is always better to transport the eggs during cooler hours
- Optimum temperature and aeration is to be provided during transportation.
- Eggs are to be carried in suitable eggs carrying box.
- Improper transportation of eggs may leads to increase in the incidence of dead eggs and may lead to irregular hatching.

2. Surface Sterilization of eggs

- Egg should be dipped in 2% formalin solution for 10-15 minutes (**Fig.6.10**).
- If eggs are not properly sterilized, the larvae become weak and die due to diseases and form the source of secondary contamination.
- Silkworm eggs can be safely surface sterilized on any day of development except during pin head and blue egg stage.
- In case of sheet eggs, dip the sheets in 2% formalin solution for 10 minutes and wash in running water.
- In case of loose eggs, the eggs are transferred into a cloth bag and dipped in 2% formalin solution, wash and dry in shade.

Fig.6.10. Surface sterilization of eggs

3. Incubation Procedure

On 8th or 9th day from the day of laying the embryos develop and becomes sensitive to light with accelerated growth. This stage is called pinhead stage and at this stage, the eggs are kept under total darkness either by wrapping them with black paper or keeping them in a black box or dark room for the next two days. The process is called black boxing. Thus, we can bring about synchronization in hatching of all the eggs together on the same day. There are different methods like black paper method, black cloth method and wooden box method. The duration of black boxing ranges from 48 to 72 hours after the pigmentation stage.

The eggs hatch around 10th day after the pinhead stage. The eggs are brought out of the black box or dark cover and exposed to diffuse light of the day in the early morning. This activates the process of hatching and in about 2-3 hours, almost all the eggs hatch out. Over 95% hatching is considered as good hatching.

Temperature during incubation has a great influence on the voltinism of silkworms. If the temperature is maintained at 15̊ C during incubation, the bivoltine breeds/races would tend to develop non-hibernating characteristics, (23 - 25̊ C) temperature is maintained, they tend to become hibernating ones. Rearing of hibernating eggs usually gives better crop than that of non-diapause eggs **(Fig.6.11).**

Fig. 6.11. Incubation of silkworm eggs

Management during incubation

- Spread the eggs in a single layer for providing optimum temperature and humidity.
- It required, manipulate the temperature and humidity inside the incubation device using heater, keeping water container etc.
- Position of the eggs should be changed at regular intervals in all the directions in case of sheet eggs; in loose eggs position of eggs may be changed by shaking of the eggs for exposing uniform temperature and humidity.
- During blue egg stage, the eggs are to be kept in block boxing.

Hatching and brushing of larvae

On the day of hatching, the eggs are exposed to diffused light from a tube light, bulb or natural day light inside the incubation room. The eggs when exposed to light should be provided with optimum humidity and temperature (Fig.6.12). Silkworm egg hatching generally starts in the early hours of the day after one or two hours of exposure to light in the morning and ideal time for brushing is 10 AM. Tender mulberry leaves of suitable quality are chopped at a size of 0.5 cm square and sprinkled in a thin layer on the newly hatched larvae. The rearing bed should be provided with wet foam pad around the bed and covered with another sheet of paraffin paper to complete the process of brushing. Tapping of worms or direct brushing of larvae to rearing bed should be avoided. The use of feathers during preparation of bed is advisable. Generally, the eggs are sold in two forms, sheet eggs and loose form in egg boxes. Hence, there is little variation in handling the process of brushing.

Fig. 6.12. Feeding to newly hatched silkworms

Loose egg brushing

At present the bivoltine eggs are given in the form of loose eggs to ensure the exact number of silkworm eggs. The brushing of loose eggs is different from that of sheet eggs. During the brushing of silkworm eggs the following procedure needs to be followed. The loose eggs are spread thinly on a loose egg incubation frame since the very beginning of the process of incubation followed by black boxing. After hatching, a piece of nylon net is spread over the larvae and fed with the chopped mulberry leaves and left for 2 - 3 hours. The larvae crawl on to the leaves and starts feeding. The net along with the leaves and larvae are then transferred to the rearing tray (Fig.6.13).

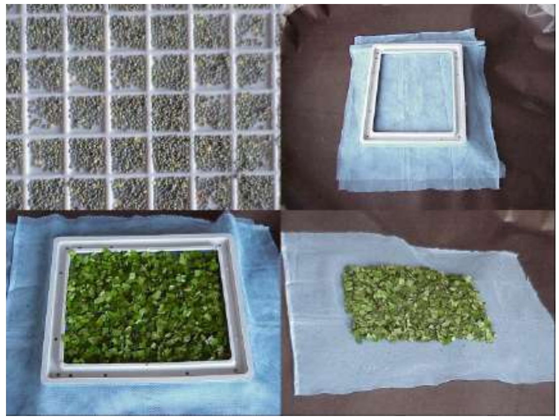


Fig.6.13. loose egg brushing of larvae

6.3.4. Chawki rearing

The young silkworms (Fig.6.14) usually up to the end of second instar are called chawki worms and they are tiny and delicate and hence the chances of damage are much brighter during handling. They require highly nutritive and succulent mulberry leaf. At this stage, they require a slightly higher temperature (26 - 28°C) and relative humidity (around 80 - 90%) than their later stages. Their growth rate is also slightly higher. Chawki rearing involves providing the young silkworms tender succulent leaves cut to size, maintaining their freshness by preserving the leaf moisture content, providing its required environment during feeding and moulting and sanitation (Fig.6.15).

Fig. 6.14. Healthy chawki silkworms

Fig. 6.15. Chawki silkworm rearing tray with rearing bed

Leaf quality for chawki rearing: Since the worms are tiny in size, chopped leaves are spread uniformly on the worms in rearing bed so that the worms can have easy access to the leaves for feeding. It also helps in loosening and spreading the bed when the bed is required to be dried prior to feeding and also at moulting. Presently it is recommended to feed different instars of worms with different sizes of chopped mulberry leaves. Being too small and tender, the younger silkworms feed on the surface of the mulberry leaves. They require tender, soft and succulent leaves with around 75% moisture and high nutritive value. Mulberry leaves having 27% protein, 11% carbohydrates, minerals and vitamins are considered good for rearing. On a mulberry shoot, four leaves below the largest growing leaves are well suited for the first instar larvae and next four leaves for the second instar. Hence, more attention should be given for increased nutrition (sugar and protein) and water content by altering the recommended dose of NPK through increasing P and K and also by adding more organic matter to the soil. To exploit young age rearing as a commercial venture, maintain exclusive chawki garden and follow specific pruning and harvest methods to produce maximum good quality leaves for chawki rearing. If there is no separate chawki plot, $1/6^{th}$ of the garden can be specified as chawki garden where irrigation should be repeated in every 4^{th} - 5^{th} day. The mulberry earmarked for chawki (Fig.6.16) should be pruned around 5 days later than the normal schedule.

Fig.6.16. Suitable chawki mulberry leaf

Harvesting, transportation and preservation of mulberry leaf

Higher temperature and dry atmosphere cause drying of the leaf faster. Therefore, the leaves should be harvested during cooler hours of the day, *i.e*. either early in the morning or late in the evening. The leaves plucked from the garden should be brought to the rearing house in baskets covered with wet gunny cloth to maintain freshness. Transported leaves are immediately preserved in suitable containers like leaf preservation chamber and covered with gunny cloth to maintain its moisture content.

Frequency of Feeding

Feeding of quality leaf, three times per day at 6 AM, 2 PM and 10 PM to the silkworms should be maintained while following a few precautions which are as follows.

- Avoid feeding of diseased, dusty and over mature leaves.
- Remove the undersized and all diseased worms carefully to avoid further contamination.
- Do not throw the rejected or diseased larvae here and there under any circumstances.

- Pick out such larvae by using old newspaper or unused leaf and burn them.
- Distribute the larvae uniformly in the bed during every feeding.
- Use paraffin paper to cover the worms during late age rearing in summer months.
- Feed soft leaves for about 3 - 4 feedings after IV moult in summer and gradually switch over to medium leaf followed by hard leaves.

Bed Cleaning

Cleaning of the bed should be done periodically (Table 6.3), as the worms grow in size and as the dry leaves and faecal matter accumulation builds up (Fig.6.17). This is usually carried out once in the first instar just prior to the worms settling for first moult, and in case of second instar the bed cleaning is carried out two times, once at the time of resumption of feed for the second instar larva and again 12 hours prior to the settling for 2nd moult.

- Young age silkworms are delicate and prone to diseases. Thus, maintenance of cleanliness in silkworm bed is a vital aspect to ensure hygiene during the rearing.
- Time to time bed cleaning is essential to remove unused mulberry leaves and silkworm litters accumulated in the rearing bed.
- Cleaning is done by nylon net of mesh size one cm. sq.
- Cleaning net is applied covering the full rearing bed just one feed before the cleaning time and the feeding is given above the net.
- At the time of next feeding the net along with the larvae are transferred to another tray. Further during chawki rearing, the following schedule needs to be followed.

Table 6.3. Cleaning schedule of young age silkworm rearing

Instar	Frequency	At what time to be done
I	Once	Before settling of first moult, preferably on 3rd day.
II	Two times	Just after 1st moult and before settling of 2nd moult, preferably two feedings before moult.
III	Three times	Just after 2nd moult, before settling of 3rd moult and middle of the 3rd instar

Fig.6.17. Bed cleaning and disposal of litter and bed refuge

Spacing or Bed Area

Spacing at every stage, starting from brushing of worms to second age is essential for uniform development. Through optimum spacing at every stage of rearing, starting from brushing of the worms, vigorous growth, robust health and uniform development of the entire batch of worms are ensured. For rearing of 100 Dfls of young age silkworms, 10 trays @ 10 Dfls per tray of 3' x 2' x 3' size is recommended. Overcrowding of worms does not allow the worm to grow completely due to competition of food and space. It also results into weakness of worms resulting into poor quality of cocoons. For rearing of late age bivoltine silkworm hybrids of 100 Dfls requires 800 Sq.ft. bed area (Table 6.4).

Table 6.4. Required spacing for 100 Dfls of bivoltine hybrids

Stage of the worms	Leaf feeding system		Shoot feeding system	
	Start (Sq.ft)	End (Sq.ft)	Start (Sq.ft)	End (Sq.ft)
III instar	65	150	72	210
IV instar	150	300	210	420
V instar	300	600	420	800

Moulting Care

Silkworms take normally 10 - 12 feedings (3 feeding / day) to settle for 1st moult, 8-10 feedings for the 2nd moult and 10 – 12 feedings for 3rd moult. Moulting duration is 20 - 24 hours under optimum conditions and the following care should be taken for uniformity of the batch (Fig.6.18).

- Size and quantity of leaves should be reduced before settling for moult.
- When about 90% of the larvae settled for moult, feeding should be stopped.
- Slaked lime powder should be dusted to reduce bed humidity during seasons with high humidity.
- The rearing bed should be maintained as thin as possible to reduce bed humidity. Paraffin paper on the top of the silkworm bed and wet foam pads should be removed in case of Box Rearing.
- When around 90 to 95% silkworms are out of moult bed disinfectants are to be dusted.
- After half an hour of dusting, feeding should be given.

Fig. 6.18. Dusting of lime during moulting stage of the worms

Environmental conditions for young silkworms

Temperature: The environmental factors (Table 6.5) like temperature, humidity, light and air have great influence on growth and development of silkworm. These factors directly or indirectly control the physiological activities of silkworm larvae. Hence, it is necessary to provide most favourable climate conditions to the silkworms at young stage.

Humidity: It exerts a direct effect on water evaporation in the silkworm's body, regulation of the body temperature and metabolism. It also influences the drying rate of mulberry leaves, the worm's appetite and the sanitation of the rearing beds. In summer, high humidity will facilitate propagation of pathogens on the rearing beds, which increases the incidence of diseases

Table 6.5. Temperature and humidity requirement during young age

Particulars	Instars		
	I	II	III
Temperature	27-28ºC	26-28ºC	26-27ºC
Relative humidity	85-90%	85 - 90%	80%

Light

- For uniform development of the silkworms, direct or one-sided light on the rearing bed should be avoided.

- Silkworm prefers dim light of 15-30 lux and it requires a minimum 16 hours light per day.

Chawki Rearing Centers (CRC's)

It is believed that, to ensure the bivoltine crop success the chawki worms needs to be reared on scientific lines by providing optimum conditions as per the technical recommendations. Further it is also believed that chawki raring raises robust healthy and uniform worms resulting in assured cocoon crop (Fig. 6.19.) To provide all such conditions required for chawki silkworm rearing, farmers may not be having devices for regulation of temperature and humidity or sometimes the farmer himself may not be aware of chawki silkworm rearing. Under these circumstances, the commercial chawki rearing centers have come into picture. These centers rear the silkworm's up to 2^{nd} moult and distribute chawki worms to the farmers rather than silkworm eggs.

Rearing of larvae upto second age is conducted at chawki rearing centers organized under expert technical supervision. The main aim of conducting chawki is to have uniform growth of worms for higher cocoon yield. To harvest quality cocoon crop, disease free silkworm eggs and succulent mulberry leaves are essential. For rearing of 100 Dfls of chawki silkworms, 120 Sq.ft. space is required.

Fig. **6.19.** Inside view of well-maintained CRC

6.3.5. Late age silkworm rearing

Rearing of fourth and fifth instars larvae are called as late age rearing. Late age worms are more sensitive to high temperature, humidity and susceptible to diseases. During this stage, the larvae grow vigorously and feed maximum leaves. In this instars, silkworm larvae takes mature and nutritious mulberry leaves to build their physique for producing silk protein continuously. Mulberry leaf quality and environmental factors play important role in crop success followed by the rearing technique, silkworm race or breed, silkworm eggs etc.

Methods of late age rearing

Generally two methods are suitable for rearing of late age silkworms namely, Tray rearing and Shoot rearing, which are very popular with farmers. However most of the bivoltine farmers are practicing shoot rearing method.

Tray Rearing

- Silkworms are reared in trays trays which are arranged one over the other in tiers on rearing stands.
- Rearing stands are arranged in two rows parallel to the wall with adequate space in the center, for removing the trays and for conducting the cleaning and feeding operations.
- Mulberry leaves are picked from the plants are cut to convenient size and fed to the silkworms.
- Usually 2 - 3 feedings are given in a day and nets are used for cleaning the beds.
- Labour required is high and has the advantage of accommodating more silkworms in a limited area.

Shoot Rearing

- At present in Southern India, it is quite common practice with the farmers to rear bivoltine silkworms.
- This is the most economical method of rearing as labour requirements for harvest of leaf, feeding and cleaning are kept at the minimal level.
- The shoot rearing (Fig. 6.20) is done by providing mulberry shoots from fourth instar onwards instead of individual leaves.
- Irrigated garden is suitable for this method. Under normal condition, 40-50 days growth period *i.e.,* from completion of one crop till the beginning of young age (second crop) required.
- In shoot rearing system, soon after third moult the larvae are shifted
to rearing shelves for shoot feeding.

Fig.6.20. Shoot rearing of silkworms

Environmental conditions:

Optimum environmental conditions needs to be ensured on priority for the success of bivoltine rearing.

- Environmental factors *i.e.*, temperature and humidity, quality of leaf supply, techniques of rearing adopted, such as feeding, cleaning, spacing etc. determine the success of silkworm crops.
- Temperature and humidity requirement during late stage silkworm rearing are to be maintained (Table 6.6).

Table 6.6. Temperature and Relative humidity during late age

Particulars	Instars	
	IV	**II**
Temperature	24 - 25ºC	23 - 24ºC
Relative humidity	85-90%	85-90%

Temperature and Humidity

Temperature plays a very vital role in the growth of silkworms and has direct effect on the various physiological activities. Optimum temperature and humidity is very important for proper growth of silkworms.

- It influences directly on the physiological functions of the silkworm.
- Humidity influences on the preservation and freshness of mulberry leaf in the rearing beds.
- High humidity affects growth of late age worms and create favourable environment for outbreak of diseases.
- Usage of lime powder is advised to reduce humidity.
- Manipulate the temperature and relative humidity as per the requirement using cooling, heating and humidifying appliances like air cooler, room heater, or using ash covered burning charcoal, wet gunny cloth, sprinkling of water to the roof, providing shade around the rearing house, covering the roof with thatch, using ventilators/exhaust fan etc.

- The body temperature of the silkworm is usually affected by the temperature of the rearing bed. When there is no air flow over the rearing bed, the body temperature increases with the increase in the ambient temperature or the relative humidity.

- When the weather is hot, keeping the silkworm body temperature about 2°C lower than the air temperature is beneficial for the physiology of the silkworms particularly in the V instar.

- Good ventilation of air flow will help to reduce the body temperature of the silkworm. One should remember that if the airflow is too fast, mulberry leaf dries up quickly in the bed.

Bed cleaning during late age

Removal of unused mulberry leaves, fecal matter of silkworm, dead or unhealthy silkworms from rearing bed is known as bed cleaning.

- Accumulations of unnecessary matters build detrimental micro-climate in the rearing bed and favours rapid multiplication of micro-organisms.
- Periodical bed cleaning is necessary to maintain hygiene. The bed should be cleaned once in a day in the morning hours under tray method of rearing.

- Under shoot rearing method, if require bed cleaning is done at 5^{th} instar on 2^{nd} day by using the ropes.

Disease and Pest Management

To ensure quality cocoon production in bivoltine rearings, all the precautionary management needs to be taken (Fig.6.21 & Fig.6.22). As and when disease worms are noticed, they are to be properly disposed off. During rearing, timely dusting of bed disinfectants and lime is so important based on the environment. It is advised to use bed disinfectants after resumption of worms from moult and once during 5th instar. As a preventive measure, bed disinfectants need to be used to prevent silkworms from diseases and to ensure success in rearing. In addition to disease management, it is also recommended to control Uzifly menace in an integrated manner. Among the approaches, fix the nylon net to windows and entrance of the door to prevent the entry of Uzi fly.

Fig.6.21. Applying bed disinfectant during late age rearing

Fig.6.22. Nylon net for prevention of Uzi Fly

6.3.6. Mounting of Cocoons:

Mounting of mature larvae stands as the last activity in silkworm rearing during the process of production of quality cocoons. Transferring of mature silkworm larvae to a suitable frame to spin cocoons is called mounting. For silkworms, cocoon making is a necessity and indispensible process to get transformed into a healthy pupa and their moth. Even if the silkworm crop is healthy wrong mounting methods, spinning conditions, mounting density, mounting of immature or over matured larvae and unsuitable type of mountages can result in inferior quality cocoons. During mounting maximum labour is required in a short period. In sericulturally advanced countries, much attention is being given on mounting.

Types of Mountages to be used

The rearing of bivoltine silkworms is of very crucial and to harvest successful crops type of mountage used also is of vital importance in deciding the quality of cocoons. Based on the merits and demerits, the type of mountage needs to be selected. Improved post cocoon parameters are observed in collapsible mountage which is durable, easy to disinfect, easy to handle and requires minimum space for use and preservation. Generally it is advised for bivoltine silkworms to use rotary mountages to ensure quality cocoons. Since it requires manpower, the farmers are using plastic collapsible mountage and in some cases bamboo mountages are also used.

Plastic collapsible mountage:

- Plastic collapsible mountages are specially designed for mounting of spinning larvae.
- Height of the corrugation should be 6 cm and each mountage should have 11 corrugations.
- Ideal size of the mountage should be 60 x 90 cm, and can be placed in wooden rearing tray.
- Around 300- 400 larvae can be mounted on a mountages and old newspaper should be placed below the mountage to absorb the urination and to reducing humidity.
- Plastic collapsible mountages require less mounting space, easy for disinfection and cocoon harvesting with adequate aeration.

Rotary mountage:

- Rotary mountage consist of two components, wooden frame and card board mountage.
- For mounting mature larvae on this mountage, old newspapers are first spread on the floor and then the cocooning frame is kept on the newspaper horizontally.
- Mature larvae are collected and transferred on the frame using a plastic comb or directly.
- Some of the silkworms may fall on the newspaper, but ultimately climb on the mountage within one or two hours.
- Each frame can be provided with 1200 larvae or 80% of the capacity so that each mature larva gets a cocooning space.
- A wooden box of 120 cm width and 13 cm depth can be used for measuring and transferring 1200 larvae to the mountage.
- When all the mature larvae climb on the mountage and start spinning, the frame is lifted and suspended from the ceiling.
- Urine can be collected below the frame by providing old newspaper on a vinyl sheet or plastic tray without soiling the cocoons.

On time mounting of matured larvae:

On the 5th or 6th day of 5th instar, silkworms reduce appetite. Silkworms discharge soft light brown coloured faeces and slowly stop eating. The skin becomes transparent due to the growth of the silk gland which occupies nearly the whole body. The matured larvae raises its head, start moving around in search of a place for cocooning and passes soft litter. They crawl around to look for a place to make cocoons. Soon after feeding, mature larvae climb above the leaves as compared to premature ones which continue eating. If light in the rearing bed is not uniform, larvae move to the darker side. On completion of eating phase, naturally silkworms attain maturity. But the larvae which were not fed properly attain the maturation later. The growth of the silk gland becomes poor and the cocoons thinner. This ultimately leads to poor shell ratio, poor filament length and reelability. On the other hand, if there is a delay in mounting the silkworms after becoming mature, silk is wasted and cocoon become thinner and smaller.

Regulation of temperature and humidity during spinning

When the temperature of mounting room is low and humidity is high, the temperature is raised by heating the room, eliminating moisture at the same time. In case the temperature is over 28°C and humidity is also high, the elimination of moisture must be made by ventilation and by avoiding heating of the room. Mature larvae excrete soft watery faeces during the period from mounting to the start of spinning of cocoons. In mass rearings, this water evaporation makes the air of the room moist. In order to eliminate the moisture of the room, ventilation must be facilitated.

During rainy season and moist night, the induction of outside air must be avoided and elimination of moisture must be facilitated by heating or using exhaust. When outside air is drier than inside, the elimination of moisture is done by inducing dry air inside, opening doors and windows. Soft faeces and urine excreted by mature larvae can be collected on a mat under the mountage and can be taken out from the mounting room before it evaporates. There is close relationship between temperature, humidity and air current during spinning. Even at optimum temperature, and humidity, reelability of cocoon is improved when there is an air current. Similarly at high temperature and high humidity also reelability of cocoons can be improved if air current is provided at the time of spinning.

- 24 – 25ºC temperature and 60 – 70% humidity suitable during spinning.
- Proper aeration should be maintained during spinning.
- Bamboo chandrike should place in Varandah or under the shade in well ventilated condition.
- Direct sun light should be avoided.
- High temperature and high humidity adversely affect the reeling quality of cocoons.

Mounting Density:

- Proper mounting density should be maintained for quality improvement.
- 40 larvae / sq.ft. for bi x bi hybrid, 50 larvae / sq.ft. is recommended for multi x bi hybrid

6.3.7. Harvesting of Cocoons:

Cocoon harvesting method depends on the kind of mountage used. Before harvesting all diseased and unspun larvae along with deformed cocoon should be removed from the mountage. Those can soil other good cocoons. In most of the mountages like chandrike, plastic collapsible mountage, etc., harvesting has to be done manually, and it takes lot of labour. In the case of bottle brush mountage, harvesting can be done by hand using a short iron rake. For collapsible mountage, the frame is stretched to both sides to deform the wave shape and cocoon can be collected from both the sides.

For rotary cocooning frame, first each of the ten cardboard mountages is removed from the wooden frame after keeping it vertically. Then the dead worms, flimsy cocoons etc., are removed from the mountages. The cocoon frame is inserted on a wooden frame and cocoons are pushed out one line after another by a cocoon pusher. Cardboard frames are then folded and bundled. Pushed out cocoons hanging on the silk filament are collected by hand. If a treadle machine for pushing out cocoons from the cardboard mountage is employed, it can be ten times faster than the hand pusher and is more efficient in a mass rearing (Fig.6.23).

- Cocoon should be harvested on 5 – 6th day of spinning.
- Premature harvesting of cocoon affects the quality. To confirm the completion of pupation few cocoon are cut open and checked.
- Defective cocoons such as deformed cocoons, flimsy cocoons and double cocoons should be removed.
- After harvesting cocoons should be deflossed before taking them to market.
- Cocoon should be preserve in thin layer before marketing

Fig. 6.23. Bivoltine cocoons in a cocoon market

To ensure the ultimate success in bivoltine silkworm rearing, breed (Silkworm hybrid variety, rearing management, the quality of seed used for preparation of hybrid, feed quality, type of mountages and procedure adopted during mounting and disease management plays a major role which ultimately decides the farmer to rear bivoltine throughout the year (Fig. 6.24)

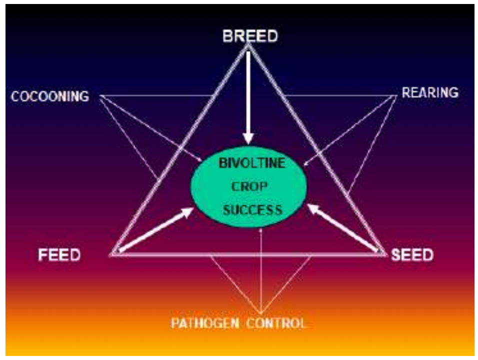


Fig.6.24. Factors responsible for bivoltine rearing success

6.4. Advantages of Bivoltine Rearing

Sericulture, the viable agro-based industry aptly matches with the socio-economic back-drop of rural India. Silk, the queen of fibres is the fruitful culmination of the cumulative and concerted efforts of the multi-disciplinary functionaries like cocoon producers, grainueres and reelers. Though India occupies second position in the overall global silk production bulk of it is from multi x bi silk. It's quality is not the low ebb compared to the existing International standards, Therefore, adoption of bivoltine sericulture became imperative and imminent considering its potentiality even under Indian tropical conditions. Success and development of bivoltine sericulture largely depends on practicing the specialized packages, skillful management in different facets coupled with rigorous R & D support. Although, considerable information is available in this direction, practical tips / guidelines helping to achieve the desired objectives are meager. Bivoltine Silk production has been one of the priority sectors of Indian Silk Industry and its production is yet to meet the targets. India is the second largest producer of silk after China and the biggest consumer of Raw Silk and Silk Fabric. Bivoltine rearing is being encouraged with the farmers to produce high quality Bivoltine cocoons (Fig. 6.25) which in turns for international grade silk.

1. The Tropical bivoltine Sericulture technology developed has given an unprecedented success in the three southern states of Karnataka, Andhra Pradesh and Tamil Naidu.

2. **High returns:** The farmer who opts for rearing of bivoltine always gets higher returns than cross breed (CB) rearer by utilizing the same resources. Sericulture as a remunerative crop can suit all categories of farmers from small/marginal farmers with meager resources to a large farmers. With short gestation periods, the returns are quick.

3. Only sericulture can generate vast employment. No other industry generates this kind of employment. Hence, it is used as a tool for rural economic reconstruction.

4. Commercial bivoltine hybrids suitable for tropical agro climatic conditions are available. Scope of harvesting successful crops even with marginal farmers.

5. There is a demand for quality bivoltine silk in the global market and as well in the domestic market. The production of bivoltine silk reduces imports and inturns fetches high prices to the sericulture farmer.

6. Rearing of bivoltine silkworms encourages filatures and auto matic reeling machines which reduces production of less quality silk through country charakas.

7. Production and productivity of silk could be increased in the country.

8. Crop insurance schemes have been offered specially to bivoltine farmers to protect against any failure. In remote rural areas, farmers are supplied with pamphlets or other essential details of methods of rearing, use of bed disinfectants, insecticides, etc.

9. Incentives and support from the government is quite praiseworthy for the production bivoltine silk in the country.

10. Since the rearing of bivoltines, generates high income to the farmers and more number of new and non-traditional farmers are attracted to the Sericulture. In such circumstances, it generates rural employment and scope for reduction of migration to urban areas.

11. The renditta ranged from 5.5-6.0 and silk graded 2A - 4A which could meet the demand of quality silk for both domestic and export market.

12. It is envisaged that the successful large scale practicing of these technology fulfill the requirement for production of quality silk in the country.

Fig. 6.25. Quality bivoltine cocoons

6.4 Summary

- *In this chapter care that needs to be taken in each and every aspect for bivoltine rearing is discussed in nut shell manner.*
- *The bivoltine silkworms produce cocoons with high raw silk recovery and bivoltine silk excels in quality.*
- *To produce quality silk, farmers are being motivated towards bivoltine sericulture.*
- *For ultimate success in bivoltine silkworm rearing, rearer needs to take care in and every aspect of silkworm rearing right from disinfection, procurement of chawki worms, late age silkworm rearing, management of environmental conditions, moulting, spinning care needs to be taken on priority.*

- *To fetch the highest price in the market, after harvesting the cocoons needs to be deflossed and accordingly sorted out to fetch better price in the market.*

- *Recommended mulberry varieties for chawki silkworm rearing are S36, V 1 and G2.*

- *Disinfection needs to be carried out systematically as per the technical guidelines*

- *Eggs are incubated at 25°C and 80% RH. Light for 16 hours and 8 hours dark.*

- *During moulting slaked lime may be dusted for providing dry conditions and hastening the moulting process.*

- *Shoot rearing is preferable at late age rearing as it is labour saving and easy way rearing.*

- *The following are very important factors for deciding the success in bivoltine sericulture*
  - *(A) Disinfection and hygiene maintenance*
  - *(B) Quality Mulberry Leaf as a feed*
  - *(C) Better Silkworm races and quality seeds*
  - *(D) Chawki rearing worms procured from authorized CRC's where the worms are reared on scientific approach*
  - *(E) Adequate spacing and moulting care during silkworm rearing*
  - *(F) Mounting in ventilated place with good mountages*

- *It is recommended not to use cow dung for trays. Disinfect the rearing room and equipments with disinfectant solution as per the recommendation.*

- *During incubation process, 48 hours before black boxing of the eggs needs to be done for uniform hatching.*

- *Glossy leaves are preferable for chawki worms; Matured leaves for late ages.*

- *Rotary mountages are ideal in ensuring quality cocoons but these devises are very laborious.*

- *However at present in the field sericulture farmers are using plastic collapsible mountages for mounting purpose as the* *method is very easy to adopt and saves so much of labour for mounting process.*

Short Answer Type Questions

1. Define C R C.
2. What is disinfection?
3. What is incubation?
4. List various bivoltine breeds developed by R & D institutes.
5. Environmental conditions required during chawki rearing.
6. Environmental conditions required during late age silkworm rearing.
7. Describe black boxing of eggs.
8. Type of mountages
9. Advantages of Rotary Mountage.
10. Features of a good mountage

Long Answer Type Questions

1. Write notes on disinfection of Bivoltine Rearing Room and equipments and various precautions to be taken during silkworm rearing.

2. Write a detailed answer on the various breeds / hybrids developed or used in sericulture industry.

3. Environmental conditions required during silkworm rearing at each stage and how do you regulate or manage them.

4. Write a detailed note on the incubation and its process? How do you regulate environmental conditions during incubation process.

5. Explain in detail about mounting process and various mounting devices along with their merits and demerits.

6. Write about the advantages of bivoltine silkworm rearing.

UNIT 7

Silkworm Anatomy

Structure

Learning Objectives

After studying this unit, the student will be able to,

- Study the anatomical structure and functions of silkworm larva, moth, digestive system and reproductive system.
- Know the structure and functions of silk gland.

7.1. Introduction

The anatomy of larva is different from that of pupa. The anatomical changes required for the formation of adult anatomy are brought in the pupal stages. When the larva or adult is cut open mid dorsally or laterally, the organs which are exposed in the body cavities called viscera. The visceral organs revealed in larva are dorsal blood vessel, alimentary canal, malphigian tubules, tracheal bushes, silk gland, ventral nerve cord and fat body. Moth visceral organs are partially hidden by the fat body in the abdomen and muscles in the thorax which are extensively developed. The organs that can be identified are heart, alimentary canal, malphigian tubules, tracheal bushes, nerve cord, reproductive organs and fat bodies.

7.2. Digestive system of larva and moth

A) Larva

The digestive system in silkworm larvae (Fig. 7.1.) is a straight tube extending from mouth to anus. The alimentary canal can be divided into three regions Stomodeum or fore gut, Mesenteron or mid gut, and Proctodeum or hind gut. The alimentary canal is made of three layers, Tunica intima which protects the alimentary canal from abrasive action of food. The Epithelial layer, which will have gland cells helps in absorption and digestion .The Muscle layer comprised of circular and longitudinal muscle layer. The digestion of food in larva is peristaltic in nature.

Fore gut (Stomodeum): The anterior part of alimentary canal *i.e.* fore gut comprises buccal cavity, pharynx leads into oesophagus. The oesophagus connects the fore gut with mid gut. A valve is observed between the oesophagus and mid gut called cardiac valve, this will help to prevent the flow of food back from mid gut to fore gut. The colorless saliva is secreted by a pair of salivary glands, which are present in buccal cavity. The saliva contains an enzyme called amylase; it helps in digestion of leaves. The pharynx is a small tube and has three pair of muscles which help the larvae to swallow the leaves due to contraction and expansion.

The esophagus is narrow at the anterior end and gradually widens to posterior end. The mulberry leaves chewed in the fore gut remains for a short, and then it enters into mid gut. Ingestion; In the fore gut the mandibles crush the leaves ingestion of food starts in newly hatched larvae after about 20 - 60 minutes of hatching. The time varies from race to race and the process of ingestion and digestion are influenced by environmental conditions.

Midgut (Mesenteron): The mid gut ranges from 2nd to 9th segment. Digestion and assimilation takes place in mid gut only. The walls of mid gut consist of muscular layer, basal membrane, epithelium and peritrophic membrane which is chitinous structure. The epithelium is formed of goblet cells and cylindrical cells. The goblet cells secretes digestive juices and cylindrical cells are absorptive in nature, the cytoplasm of cylindrical and goblet cells has mitochondria and golgi apparatus.

The mitochondria involve in secretary activity. Digestive juices can be divided into saliva and gastric juices. Saliva is a weak alkaline contains enzyme called amylase. Gastric juices are strong alkaline having PH from 9.2 to 10.3, which is due to presence of sodium in the blood.

Hind gut (Proctodeum): The hind gut comprises small intestine colon and rectum. It forms from invagination of outer ectoderm. There is a pyloric valve at the junction of hind gut and mid gut, which will regulate the passage of food from mid-gut to hind-gut and restricts the reverse flow. The malphigian tubules arise at the junction between small intestine and colon and opens into rectum. The main function of malphigian tubules is metabolism. The nitrogenous compounds are metabolized and excreted as uric acid and also excretes calcium oxalate. The colon extends into rectum to anus. The rectum narrows towards anus. The rectum has six muscles which help to eliminate the excreta by pressing the muscles. The faecal matter is released out through anus. The time taken for food to travel through the entire alimentary canal varies from 2 – 4 hrs to 4 – 5 hrs.

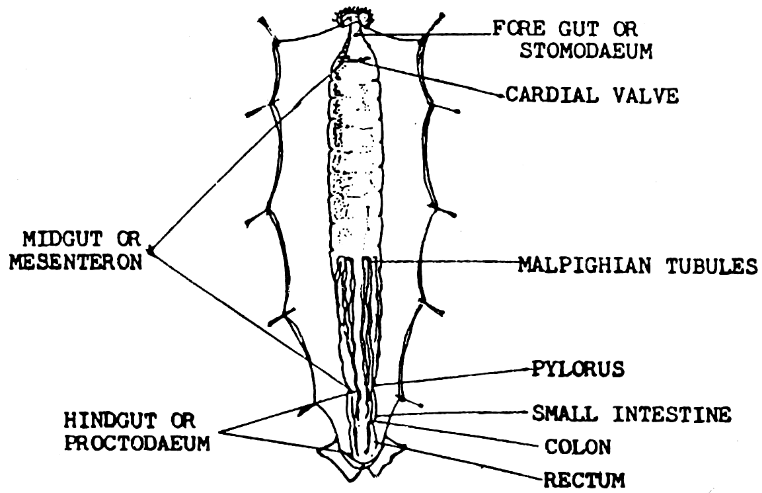


Fig. 7.1. Digestive system of larva.

A) Adult

The moths do not feed and hence the alimentary canal is very much reduced. The adult fore gut has a tubular oesophagus followed by the stomach and the sucking stomach which are in the mid-gut posterior then hind-gut. The rectal sac arises from rectum ends in the anus.

The alimentary canal has no digestive function. The alimentary canal of the newly formed moth is presumed to secrete the alkaline eclosion fluid which digests the cocoon for the emergence of the moth. The secretion contains a protease which attacks and dissolves the sericin of the cocoon, which facilitates for breaking the cocoon. The other function is the storage of air swallowed by the newly emerged moth for distending its body and wings.

7.3 Silk gland

The silk thread of the cocoon is secreted by a pair of silk glands which are actually modified labial glands. These dermal glands are well differentiated in the fourth and fifth instar larvae. They lie below the alimentary canal and are so large in the fully grown final instar larva that it occupies most of the body cavity ventral to alimentary canal and accounts for about 50% of the weight of the larva. The silk glands (Fig. 7.2.) are tubular in nature and the width of the tube varies in different regions of the gland. The entire gland is formed of three layers. The outer tunica propria is of uniform thickness, the middle glandular layer and the tunica intima is of varying thickness. There are three distinct regions in the silk gland differing in structure and function. They are the posterior region, the middle region and the anterior region.

The posterior most region is folded and the folds are in the midst of the dermo-visceral muscles. They secrete the major protein of silk namely 'Fibroin'. The middle region is the most prominent region of gland and is also the widest. It is folded into a w-shaped structure and hence has three limbs, the posterior, the middle and the anterior limb. The middle region acts as a reservoir of the fibroin secreted by the posterior region and fibroin matures in this region during storage period. The layer of sericin secreted by the posterior limb of the middle region is called Sericin I, that added around Sericin I by the middle limb is Sericin II and added around Sericin II by the anterior limb is Sericin III.

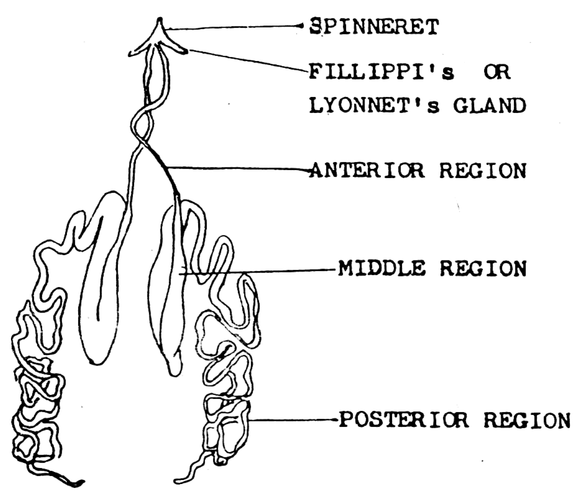


Fig. 7.2. Silk gland

The anterior region is of uniform thickness and is very thin; it does not secrete any material and serves only to conduct the silk fiber assembled in the middle region to the spinneret. The anterior region of the two sides open at the base of the median projection in the labium called spinneret which draws out silk in the form of a fine filament.

A pair of Fillip's gland open into the silk gland at the junction right and left anterior parts of gland and it is assumed that this gland secretes some waxy material which covers the silk filament.

7.4. Reproductive system of larva and moth

(A) Larva

The reproductive system of the adult is represented as the genital imaginal disc in the larva. It is clearly visible in the fifth instar larvae. It consists of the gonad (ovary in the female and testis in the male) and the band or duct in a rudimentary condition. In addition, the female has a pair of Ishiwata's gland in the eighth and ninth segments and the male have a pair of Herold's gland in the ninth segment.

(B) Moth

Female: The female reproductive system consists of a pair of ovaries with four ovarioles occupying the entire abdominal cavity. The ovarioles are covered by a sheath, which has muscle fibers.

The ovarioles are polytrophic. In each ovariole there is a succession of nutritive cells surrounding an egg cell which they nourish. The ovarioles of aside unite to form an oviduct. The two oviducts join to form the common oviduct which opens to exterior by the female genital pore. Arising from the junction of the two oviducts is a sac- like structure called bursa copulatrix. This opens to the exterior by the opening called ostium bursae. The male transfers the spermatophores through the ostium bursae to the bursa copulatrix from where they are transferred to the common oviduct serve to store the sperms received during copulation.

A pair of accessory gland lies dorsal to the common oviduct and they secrete the adhesive glue by which the eggs are attached to the substratum (Fig. 7.3).

Male: A pair of testes are present on the fifth abdominal segment on either side of the ventral nerve cord. Each testis is formed by a number of seminiferous tubules. The vasa efferentia of each side unite to form the vas deferens. The two vasa deferentia have each an enlarged seminal vesicle situated in the middle. From the seminal vesicle arises the ejaculatory duct opening into the male genitalia the aedeagus.

A pair of accessory gland opens by a common duct into the seminal vesicle. The secretion of the accessory glands serve to pack the sperms in a membranous sac to form the spermatophores (Fig. 7.4.).

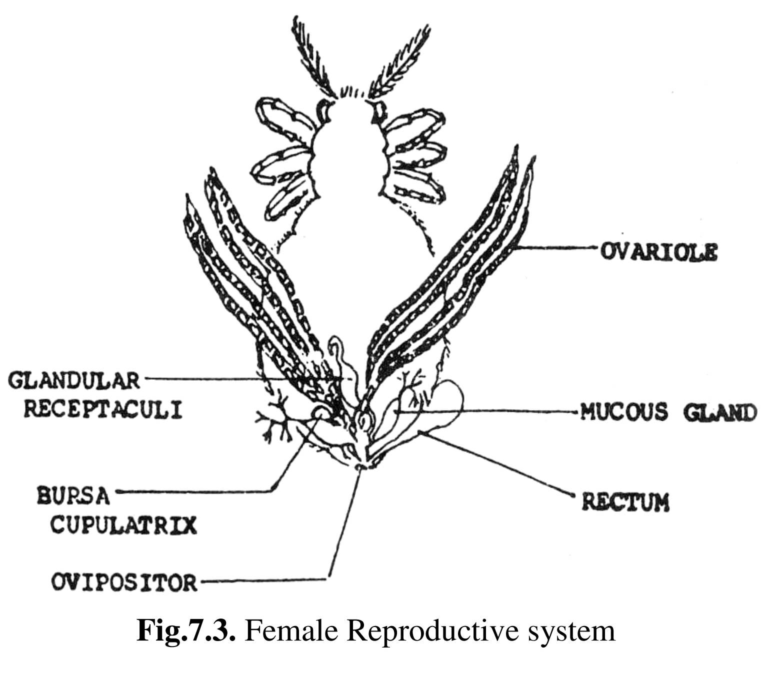


Fig.7.3. Female Reproductive system

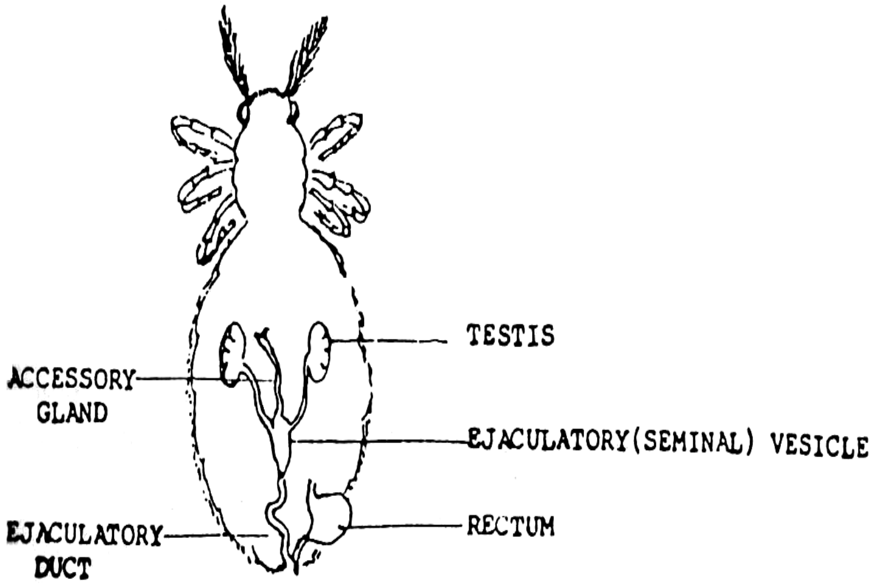


Fig. 7.4. Male Reproductive system

Summary

- *Study of an organism by dissecting the body and opening the body cavity is called anatomy.*
- *The visceral organs of larva are dorsal blood vessel, alimentary canal, ventral nerve cord, fat body, except silk gland all are seen in moth.*
- *Alimentary canal is a straight tube extending from the mouth to anus.*
- *Digestive system is divided into three regions fore gut, mid gut and hind gut which are called stomodeum, mesenteron and proctodeum.*
- *Fore gut region function is reception and storage of food, the mid gut is the region of water reabsorption.*
- *A pair of silk gland is modified labial glands.*
- *There are three distinct regions in the silk gland differing in structure and function i.e., posterior, middle and anterior regions.*
- *The posterior region which secretes the core protein fibroin, the middle region secretes sericin in three layers I, II, III and anterior region acts as a passage to reach spinneret.*
- *The female has a pair of Ishiwata's gland in the eighth and ninth segments and males have a pair of Herold's gland in the ninth segment. It is clearly seen in the fifth instar larva.*
- *The female reproductive system consists of a pair of ovaries with four ovarioles.*

- *Pair of testes is present in male moths on the fifth abdominal segment.*
- *A pair of accessory glands in females secrete glue for adhesion of eggs, whereas in the males they serve to pack the sperms*

Short Answer Type Questions

1. Name the parts of digestive system of silkworm.
2. What is the function of cardiac valve?
3. Mention the function of foregut, midgut and hind gut.
4. Name the proteins secreted in the silk gland.
5. How male and female larva is differentiated?
6. What is the function of accessory glands in male and female moths?
7. What is the time taken for processing of the food?
8. What is the function of adult digestive system?
9. What are the digestive juices secreted in digestive system?

Long Answer Type Questions

1. Describe in detail about the digestive system of silkworm larva.
2. Write about the structure and function of silk gland.
3. Give an account on female reproductive system with a neat sketch.
4. Detail the male reproductive system of moth.
5. Detail the female reproductive system of moth.

UNIT 8

Silkworm Diseases and Pest Management

Structure

8.1 Introduction

8.2 Protozoan disease

8.3 Bacterial disease

8.4 Viral diseases

8.5 Fungal diseases

8.6 Pests (Major and minor pests)

8.7 Integrated disease and pest management

Learning Objectives

After studying this unit, the student will be able to,

- Know and study the various diseases of silkworms.
- Identify and study about the pests of silkworms
- Understand the precautions and control measures to be taken for control of diseases and pests.

8.1. Introduction

Among many constraints that influence the success of cocoon production, the menace of diseases is the prime one. Sericulture farmers have been striving constantly to minimize the incidence of diseases and maximize cocoon production.

Silkworms are not exceptional for attack of diseases and pests. As they are commercially exploited organism it is prone to more diseases and pests. Due to centuries of domestication, the silkworms last natural resistance and don’t show any adaptation to escape from it. Silkworm suffers from a number of diseases caused by microsporidia, fungus, virus, bacteria and sometimes a combination of two different pathogens. These diseases cause considerable damage to the cocoon crop at farmer's level. The pathogens circulate from leaf storage, litter, store room to rearing house (Fig. 8.1) and prevail in the rearing room if proper disinfection is not carried by the farmer. Further, the disease causing pathogens enter into the silkworm through wounds or per orally along with mulberry leaf (Fig. 8.2.). It is therefore imperative to implement an integrated silkworm disease management technology so that the cocoon productivity levels can be increased by controlling the diseases. Generally, healthy and hygienic rearing reduces the incidence of diseases. However with adaptation of improved silkworm rearing technology, use of certain bed disinfectants and chemicals for the prevention of diseases and pests, the cocoon productivity has increased in recent years. Apart from the diseases, silkworm pests also cause considerable damage to cocoon crop. Uzifly is the major pest responsible for loss about 10% of the cocoon production. The common diseases and pests are dealt in this chapter and the reasons for disease prevalence are as follows.

- Improper disinfection
- Persistence of pathogens
- Poor sanitation or hygiene
- Susceptible silkworm breeds
- Poor maintenance of mulberry garden
- Inadequate spacing
- Adverse climatic actors
- Poor rearing management

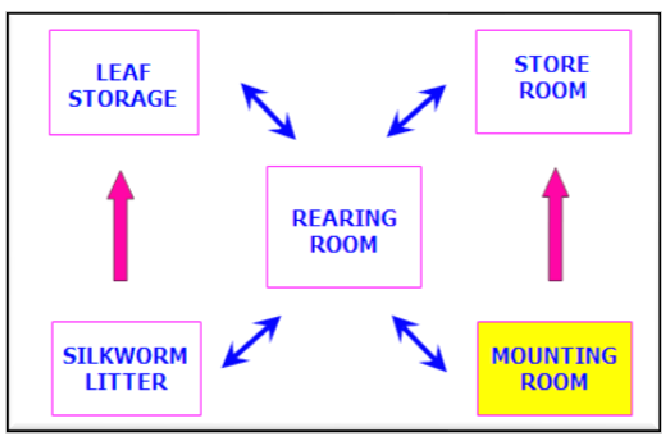


Fig.8.1. Circulation of pathogens in a rearing room

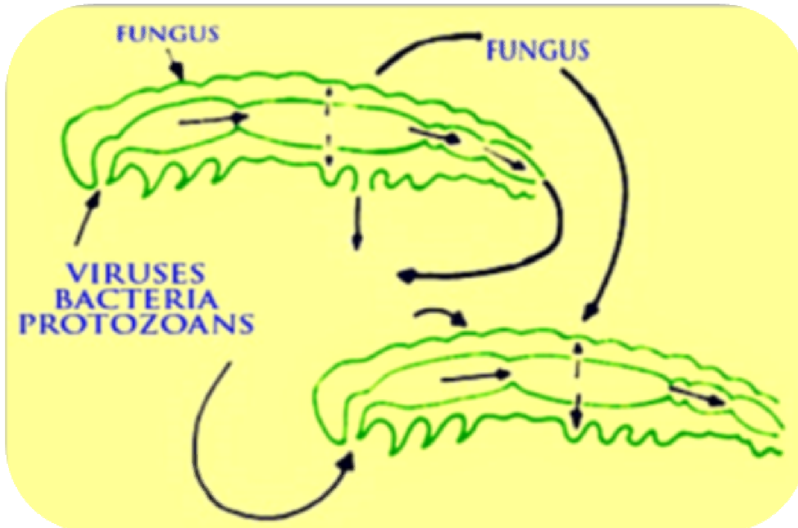


Fig.8.2. Route of pathogenic infections

8.2 PROTOZOAN DISEASE

The protozoan disease of silkworm is popularly known as Pebrine. The name 'Pebrine' was coined by De Quatrifages because of the characteristic infection and appearance of dark pepper like spots on the body of the infected silkworm larvae. The disease spreads very quickly and assumes epizootic importance, the entire silk industry of France and Italy would have been wiped out if Pasteur's discovery was not come into result for the cause and control for this disease. Its first record was made during 1845 in France.

Causal organism: The disease is caused by *Nosema bombycis* Nageli and its systematic position is as follows.

Phylum	: Protozoa
Class	: Sporozoa
Sub-class	: Cnidosporidia
Order	: Microsporidia
Family	: Noseamtidae
Genus	: Nosema

Species : bombysis

Mode of transmission

Oral: Feeding of contaminated mulberry leaf

Contact: The infected larva in the rearing bed liberated spores enter through skin wounds of healthy worms.

Life cycle of *Nosema bombycis*: The life cycle of the parasite is completed within a single host, the silkworm. There are two stages in the life cycle.

i) Spore stage: This is a resistant and infective stage.

ii) Vegetative stage: It is a growing stage.

i) Spore stage: The mature spore is oval or ovocylindrical it measures approximately 3.4 x 1.5 x 5.4 microns and refracts light (Fig. 8.5). The spore stage is also called sporont. The spore has a protective thick tunic called spore capsule. Two large vacuoles present at the two poles restrict the protoplasm to a girdle like structure in the middle. It is called sporoplasm and is binucleate. At one end of the spore capsule is a bag-like structure called polar capsule. The bag extends to the other end through the interior of the sporoplasm. Along polar filament (30 times as long as the body) is kept coiled inside the polar capsule. The polar filament opens to exterior by means of a small opening called micropyle. The spore can survive in ordinary conditions of aerating house for more than one year.

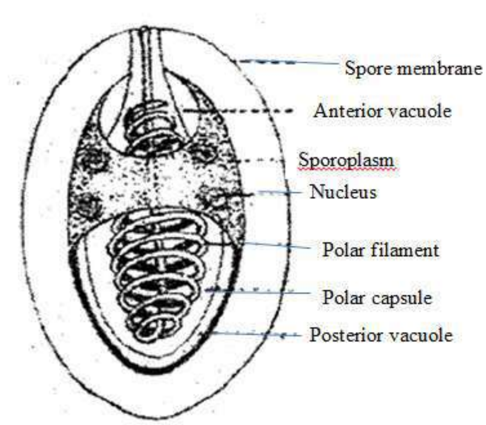


Fig. 8.3. Structure of Pebrine spore

ii) Vegetative stage: When live spores enter into the silkworm through mulberry leaf, they germinate in the gut due to high alkalinity and potassium ions. As a result the polar filament is extruded and the sporoplasam along with two nuclei creeps through it and injects into the mid gut tissues. Subsequently the polar filament gets digested in the alimentary tract. The two nuclei of the sporoplasam unite to form a uninucleate 'planont'. The planont measures 0.5- 1.5 microns and is formed in 1-2 days and multiplies by binary fission and penetrates through the gut epithelium, enters the haemocoel and infects various organs like fat body, trachea, silk gland and reproductive organs. This is called "autoinfection".

Planonts are extracellular, motile and uninucleate and divide by binary fission and produce vegetative planonts. Once the planont penetrates the host cell, it transforms into a sedentary form and becomes localized. This stage is known as 'Meront'. This is an intra-cellular stage and has a definite cell wall immobile which absorbs nutrients from host cell and are larger than planonts. They grow and undergo multiple fission. The products are the spores when cytoplasm of the host cell is exhausted; meronts are arranged in parallel rows. Ultimately, the cells die and liberate the spores.

Symptoms: The symptoms of this disease can be observed in all the stages of silkworm *i.e.* egg, larvae, pupa and adult.

Egg stage: The eggs are over lapped, more of unfertilized and dead eggs indicating pebrine infection. Poor and irregular hatching or immediately after hatching they may also die. The infected eggs have insufficient or irregularly deposited glue and hence get easily detached from the egg card.

Larval stage: The larvae show poor appetite, retarded growth and development leading to unequals. Larvae moult irregularly and show sluggishness. Trans ovarially infected larvae die before third moult but those heavily infected dies during first instar itself .

The larval body shows wrinkled skin with rustic brown colour. The affected gut becomes opaque and the silk glands show white pustules in different places along its length. Sometimes black irregular pepper like spots are noticed on the larval skin (Fig. 8.4.).

Fig.8.4. Pebrine affected larvae

Fig. 8.5. Microscopic view of pebrine spores

Pupal stage: The infected pupae are flabby and swollen with lusterless and softened abdomen. Sometimes irregular black spots are noticed near the rudiments of the wing and abdominal area. Highly infected pupae fail to metamorphose into adults.

Moth stage: The moth emergence is delayed and improper. They have clubbed wings with distorted antennae and do not mate properly. The scales from wings and abdominal area easily come off. In infected moths if the accessory glands are infected, the moth may lay eggs with less gluey substance resulting in the detachment from the egg cards (Fig. 8.6).

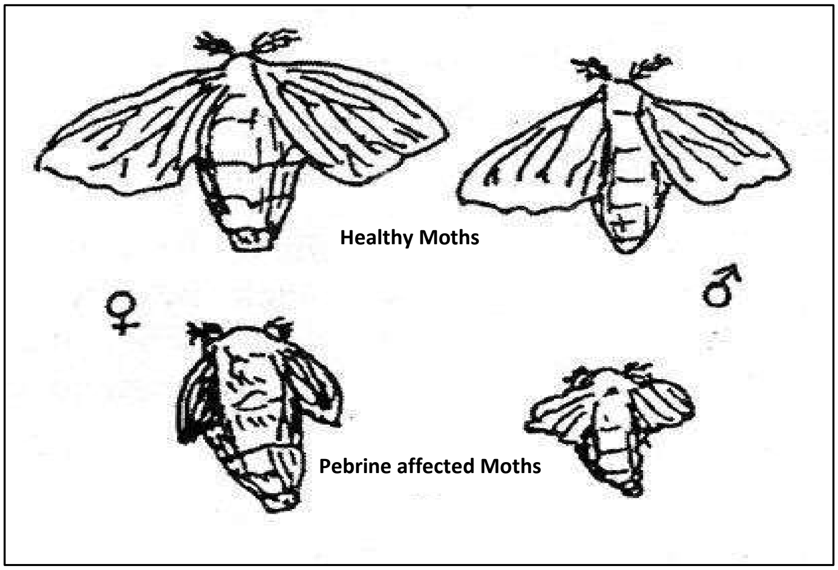


Fig. 8.6. Pebrine infected moths

Prevention and control

1. Rearing of disease free layings.
2. Effective disinfection and maintenance of hygienic conditions during rearing.
3. If infection is detected before 3rd instar, the crop may be rejected.
4. During silkworm rearing, the silkworm pellets are tested periodically and if spores are detected, the infected crop should be rejected.
5. Collect and burn the diseased eggs, larvae, pupae and moth, bed refuges, faecal pellets, etc.
6. Practice hygienic measures during silkworm rearing as well as silkworm egg production.
7. Mother moth examination for pebrine disease in silkworm egg

production should be conducted strictly.

8. **Mother moth examination:** The emerged moths are subjected for individually or sample of moths by using porcelain composite crushing set. 20 moths are homogenized in 80 ml of 0.6 % K_2CO_3 using mortar and pestle. The homogenate obtained is examined under microscope at 600 magnification for perbrine spores. The moth tester should examine 5 fields in a smear to ensure the detection of spores. The individual moth homogenate is certified as free of infection if spore is not detected.

If the homogenate from a group of 20 moths tested individually are grouped to contain 20 moths homogenate and are subjected to group mother moth examination procedure for testing the smear. If the homogenate is free from infection, all 20 eggs are confirmed as free of Pebrine. If a pebrine spore is detected, the whole group of 20 layings is destroyed.

Method of Crop Monitoring:

The process of monitoring with reference to pebrine starts from the egg stage itself and the procedure is as follows at each stage.

Egg stage: The unhatched /dead eggs should be crushed with 4 times the volume of 0.6% K_2CO_3 solution, filtered through absorbent cotton layer or 2-3 layers of muslin cloth and centrifuged at 3000 rpm for 5 minutes. The sediment is microscopically examined at a magnification of 600. If spore stage of microsporidian is observed, the crop should be rejected.

Larval stage: The small, unmoulted and apparently sick larvae are collected and microscopically examined in the same method as described for eggs. If the spore stage of microsporidian parasite is observed, the crop should be rejected at once following proper method of disposal of diseased material.

Pupal stage: Pupae are homogenized by adding 0.6% K_2CO_3 (9 ml/pupa). The homogenate is filtered and centrifuged as described for egg and larval stages. If sediment revealed the presence of microsporidian spores, such cocoons are not purchased for seed production.

Examination of dust: The dust from rearing room, floor, wall, seed and soil in front of rearing house should be tested by adding 0.6% K_2CO_3 (4 times the weight of dust) by mixing thoroughly. Decant the supernatant, centrifuge and microscopically examine the sediment for microsporidian spores, if any.

8.3 BACTERIAL DISEASE

Bacterial diseases effecting silkworms are collectively known as flacherie disease. Flacherie is a syndrome typified by flaccid condition of the affected larvae and caused by non-occluded viruses, bacteria and both in combination. In vernacular languages, the disease is also called as Sappe, Thatte Roga, Kenchu etc. The incidence of flacherie is high during hot and humid seasons. The outbreak of the disease is due to fluctuation of environmental conditions, under nourishment, accumulation of litter in rearing beds *i.e.* unhygienic conditions etc. Bacterial diseases of silkworms are divided into three major types namely Bacterial septicemia, Bacterial disease of the digestive tract and Bacterial toxicosis.

8.3.1. Bacterial Septicaemia

Causal organism: Bacillus, Streptococci and Staphylococcus

Site of infection: Haemolymph

Source of infection: Injury or rarely orally.

Symptoms: The common symptoms like sluggish movement, decreased appetite, straightened body, swollen thorax, shrinkage of abdominal segments. Vomiting and bead like faces and loss of clasping power of legs. Further, the body becomes soft and discoloured. Body wall easily ruptures and emits foul smelling fluid. There is no much difference between healthy and diseased larval body until it dies. When the larvae vomit fluid, the body shrinks. Further soft and liquid like excrements irregular in shape may be found. The colour of dead larvae varies depending upon the kind of bacteria. However many larvae become black or grayish black in colour. In general the infected dead larvae shows swollen fore-intestine and shrunken posterior part. In case of black thorax septicemia, the darkening starts form the thorax and extend to the dorsal vessel till the whole body softens with a slightly reddish tinge. In any case, the septicemia is generally acute diseases, spreads quickly (Fig. 8.7). The time between infection and death at 28° C is round 10 hours. But in higher temperature the disease spreads quickly.


Fig. 8.7. Septicemia affected larva (Early, later stage)

8.3.2. Bacterial disease of the digestive tract

This disease is otherwise known as transparent head disease due to the bacterial multiplication in the digestive tract leading to the swelling and transparency of the head.

Causal organism: Streptococci, Coli aerogenous bacilli and Proteus group bacillus.

Site of infection: Digestive tract

Source of infection: Oral and induction by bad rearing conditions.

Symptoms: The symptoms differ depending on the time of occurrence, kind of bacteria found indigestive tract, the silkworm race (Fig. 8.8 & 8.9). General symptoms are poor appetite, sluggish, transparent head, stunted body size and retarded growth. Sometimes with oral and anal discharges. The diseased worms often hide under the mulberry leaves. In case of a late stage attack the disease worms remain in the spinning tray for a long period without spinning cocoons till they die. These are the symptoms of all flacherie affected worms but the time of infection and the progress of the disease also show certain features which are characteristic of each type of the disease.

1. Shrinking after moulting: the larva does not feed after moulting and body shrinks.
2. Shrinking: The larva body shrinks since it does not feed.
3. Diarrhoea: The fourth and fifth instar larvae pass soft excrements of irregular shape. In later stage the faeces contain intestinal membrane. A sometimes chain type excreta is observed. Often, rectal protrusion is also observed.
4. Vomiting: Larvae vomit and pass loose faecal matter (diarrhea). Then body softens, putrefies and shrinks as the time passes.

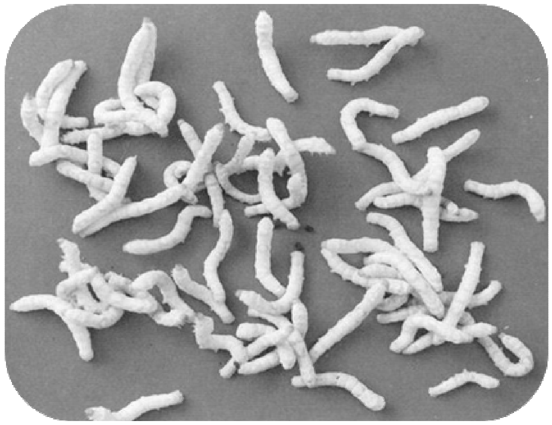


Fig. 8.8. Disease symptoms of bacterial disease of the digestive tract

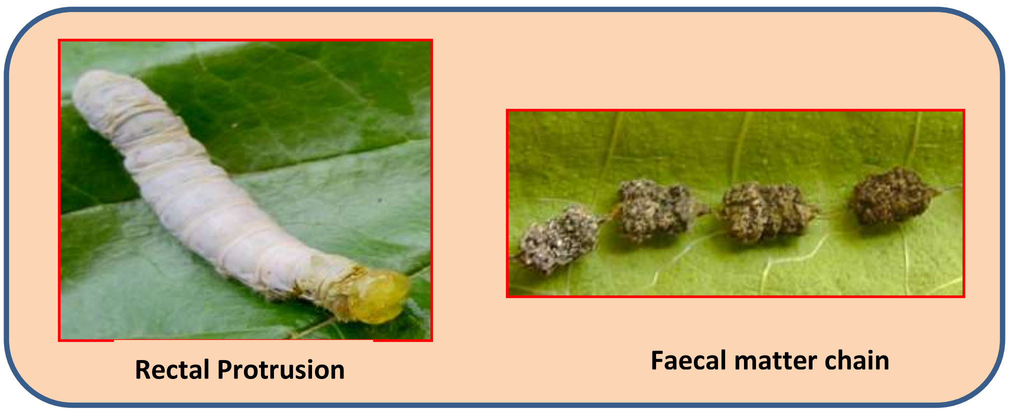


Fig. 8.9. Transparent head disease and its symptoms

8.3.3. Sotto

This disease is otherwise known as bacterial toxicosis. Worms are killed by the endotoxin produced by the bacilli. Toxin is a rhombic crystal and is released out of the cell as the bacteria collapse.

Causal organism and Site of infection: The disease is caused by different strains of *Bacillus thuringiensis* belongs to family Bacillaceae. The pathogen has a vegetative, cytocyst and spore form. The spore produces delta endotoxin. Generally infection is per oral and can also take place through wounds or injury. After entering into the silkworm body the toxic crystals are dissolved in the alkaline digestive fluid. Then the toxic substance is absorbed through the gastric wall. It affects the nervous system, causing spasm and paralysis.

Symptoms: In the beginning the worms loses appetite, becomes inactive, shows combination of flacherie symptoms and finally dies. In the advanced stage the silkworm loses appetite suddenly, writhes, affected with convulsions and dies in a short period. The victim turns gradually to brown, blackish brown or black and begins to rot (Fig. 8.10).

Fig. 8.10. Sotto disease affected larvae

8.4. VIRAL DISEASE

The viral disease is called jaundices as the infected larvae appear yellow in colour and excrete white faces filled with viral polyhedra.

Source of infection: Usually per oral and wounds / injury.

Symptoms: Infected larvae loose appetite. Suddenly show the symptoms of convulsions, lifting of head, spasm, tremors, paralysis, distress, sudden collapse of body and turns to black after death.

A virus is a biological entity which lacks metabolism but undergoes multiplication at the expense of the host cell. Viral diseases of silkworm are a major problem to sericulture. Viral disease of silkworms is of two types.

(A) **Inclusion type:** Possess inclusion bodies which can be detected through compound microscope. Nuclear polyhedrosis and cytoplasmic polyhedrosis.

(B) **Non-inclusion type**: These do not possess inclusion bodies and can be detected only through electron microscopy. Ex. Infectious flacherie and Gattine.

8.4.1. Nuclear Polyhedrosis

It is a major viral disease commonly known as Grasserie, Jaundice, Milky disease, fatty degeneration and hanging disease. The virus forms crystalline polyhedral bodies in the nucleus of haemocytes, trachea, fat bodies and dermal cells.

Causal agent: Nuclear Polyhedrosis is caused by *Bombyx mori* Nuclear Polyhedrosis Virus (*Bm*NPV).

Site of infection: Nuclei of tracheae, fatbodies, epidermis and haemolymph of silkworm body, occasionally seen in middle and posterior portion of silk gland.

Shape of the polyhedra: The virus is rod shaped and varies in size from 280 - 300 milli microns. The polyhedra is usually hexagonal rarely tetragonal.

Symptoms at the early stage of infection:

- At the early stage of disease development the infected silkworms appear normal without any morphological symptoms (Fig. 8.11).
- Microscopic examination of the blood of infected larvae reveals the presence of polyhedra in the nucleus of the blood cells.

At the later stage of Infection:

- The skin of the infected larvae becomes shining.
- The integument becomes fragile.
- Inter segmental swellings appears.
- The larvae fail to moult and move aimlessly.
- Skin of infected larvae ruptures easily and milk like haemolymph oozes out which contains millions of polyhedra.

Occurrence:

The disease occurs throughout the year. However, the severity of disease is noticed more during summer and rainy seasons.

Spread of disease:

The diseased silkworms extrude the pathogen along with the haemolymph, after the rupture of the skin. The body fluids contaminate the rearing bed, rearing house, appliances and the mulberry leaves. The disease spreads to healthy silkworm on feeding of contaminated mulberry leaves.

Management of the Disease:

1. Practice thorough disinfection of rearing house, its surroundings and rearing appliances for two times, first disinfection should be two days before the commencement of rearing and second after the completion of rearing.
2. Practice personal and rearing hygiene during silkworm rearing.
3. Collect the diseased larvae at the early stage of infection and dispose by burning or burying.
4. Apply bed disinfectants as per recommended schedule and quantity during rearing.
5. Maintain optimum temperature and humidity in the rearing house.

6. Avoid overcrowding in the rearing bed and provide proper ventilation in the rearing house.
7. Provide sufficient quantity of good quality mulberry leaf for feeding silkworms.

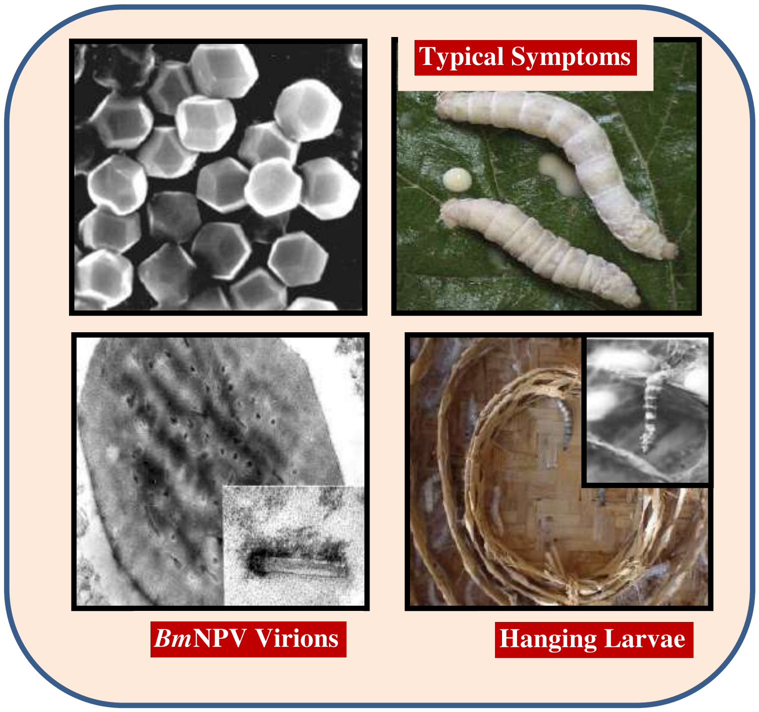


Fig.8.11. Disease symptoms of Nuclear Polyhedrosis

8.4.2. Cytoplasmic polyhedrosis:

It is one of the major silkworm diseases. It is of viral origin and difficult to control. The disease was first discovered by Ishimori (1934). Since this is a polyhedral viral pathogen multiplying within the cytoplasm of the host cell, the name cytoplasmic polyhedrosis is given.

Causal agent: Smithia virus belongs to the family Reoviridae.

Site of infection: Cytoplasam of cylindrical cells of midgut.

Shape of the polyhedral: The virus forms polyhedral in goblet and regenerative cells also showing the characteristic chalky white appearance of the whole midgut. The virus is spherical and varies in size from 60-70 Millimicrons. The polyhedra are either hexagonal or tetragonal in shape.

Source of infection: Contaminated leaves and environment. The major source of contamination and spread is the rearing bed itself as the polyhedral are excreted along with the faecal matter. The major factors influencing the outbreak of this disease are the inferior quality of leaf, high temperature and fluctuations in temperature and humidity.

Symptoms: Infected larvae lag behind of their growth and development with stunted body and dull white in colour. More unequal are seen resulting irregular moulting and if infected larva is dissected, the midgut is seen as whitish and opaque, compared to greenish midgut of the healthy larva. The whitish and opaque nature of midgut starts from posterior to anterior with the advance of disease, finally entire gut becomes chalky white.

Prevention and control:

1. The virus can persist in the form of polyhedra for more than one year inside the rearing house, hence disinfection with 5% bleaching powder and 0.5% slacked lime can control the disease.
2. Ensure proper ventilation and air circulation.
3. Collect and burn the infected larvae, faecal matter and refuges.
4. Feed the larva with nutritious mulberry leaves and during later age feeding of tender leaves should be avoided.
5. Avoid injury to the worms, overcrowding of worms and accumulation of faeces in the rearing bed.
6. Proper bed drying is necessary before each feed to avoid accumulation of moisture in the bed.
7. Dust bed disinfectant on the larvae, 1/ 2 hr before resumption from the moult (3kg/100 dfls in tray rearing and 6 kgs in shoot rearing method).

8.4.3. Infectious flacherie

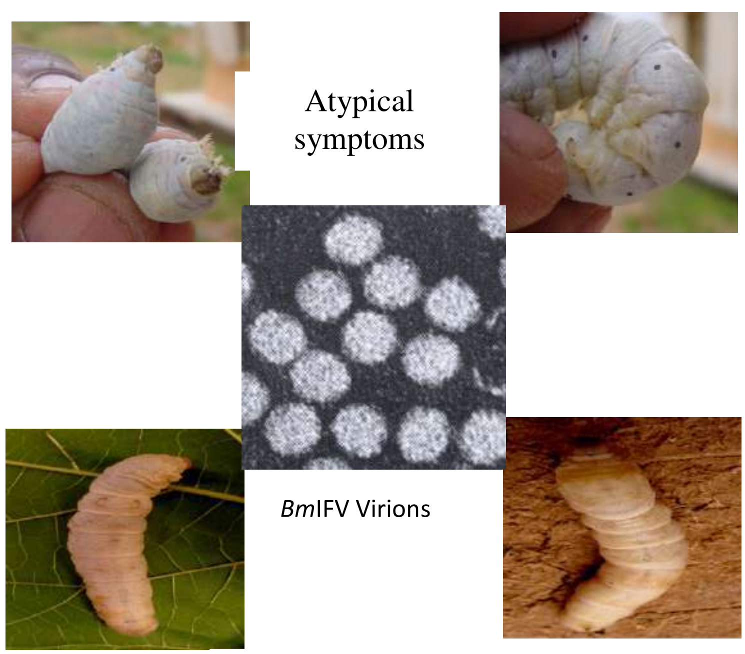
Causal agent: Morator virus belonging to the family Picornviridae.

Site of infection: Infects the goblet cells of the mid gut epithelium with advancement of the disease, the virus is dispersed in the lumen of digestive tract and excreted with faeces.

Shape of polyhedra: The virus is gobular and measures 24 - 28 nm in diameter and no polyhedra are formed.

Source of infection: Infected larvae and contaminated faeces.

Symptoms: The symptoms (Fig. 8.12 & 8.13) are similar to Bacterial flacherie, such as loss of appetite, transparent cephalothorax, body shrinkage, retarded growth and development followed by vomiting of gastric juice and diarrhoea. The midgut contains little amount of mulberry leaf and full of yellowish digestive fluid. The disease cannot be identified by external features only, histo-chemical changes of midgut can be observed under microscope.



Transparent larva

Fig.8.12. Infectious flacherie affected larva (early, late)

Fig.8.13. Mountage mortality due to *Bm*IFV

Prevention and control.

Disinfection of rearing house and appliances with 2% formalin or 5% bleaching powder solution and chlorine dioxide is effective in exterminating pathogen. Silkworm rearing under hygienic conditions and good quality mulberry leaf help in checking the disease.

8.4.4. Gattine

Causal agent: Denso virus is primary agent and streptococcus bombycis is secondary invader. An epidemic and fatal disease of silkworms believed to result from the combined action of a virus and a streptococcus.

Site of infection: Nuclei of cylindrical cells of midgut.

Source of infection: Per oral entry of faeces

Symptoms: The symptoms are clear and prominent when both virus and bacterium occurs in the larvae. It includes lack of appetite, vomiting of an alkaline clear ropy liquid from the mouth and diarrhoea. The anterior part of the alimentary canal is free of mulberry leaves and contains only the digestive fluid; these areas appear transparent and give the name of 'Clear head' to the disease (Fig. 8.14).

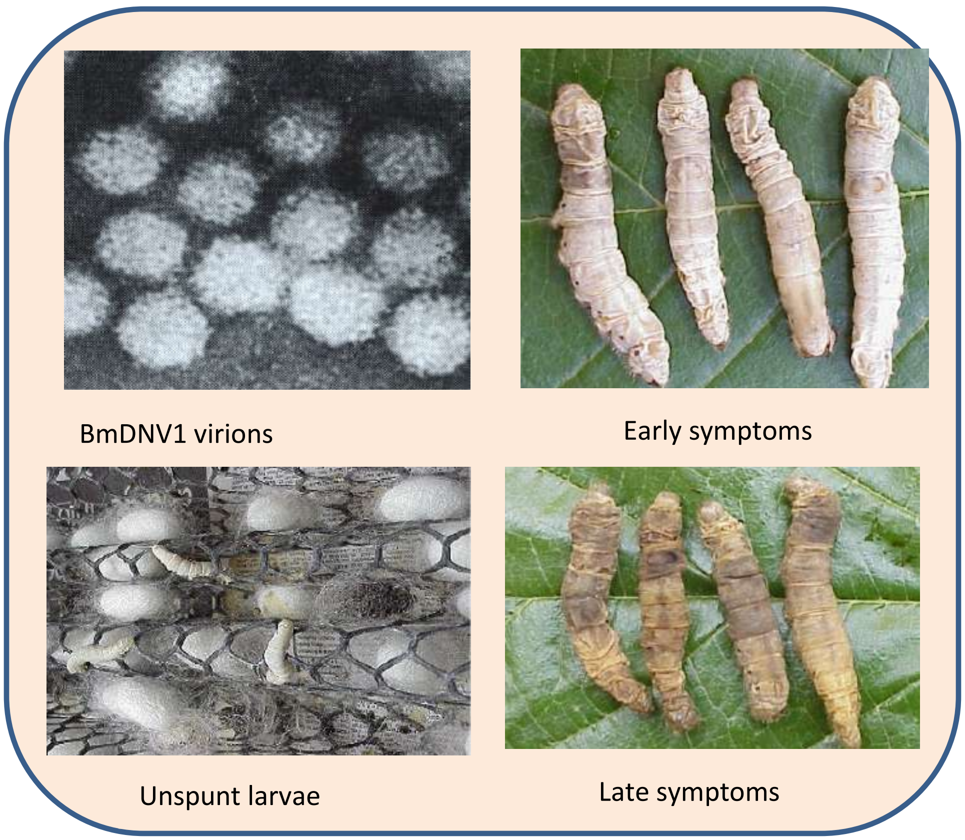


Fig.8.14. *Bm*DNV$_1$ disease symptoms

Prevention and control: Maintenance of good sanitary conditions, disinfection between rearing prevents the disease. Picking of diseased larvae and destroying them controls the spread of disease. Usage of bed disinfectants also helps in preventing the disease.

8.5. FUNGAL DISEASES

Fungal diseases of silkworms are called Muscardine. The study of fungal diseases is called Mycosis. Muscardine and Aspergillosis are fungal diseases which are common during winter and rainy seasons. Muscardine infects all the stages of silkworm and it is an air borne fungal disease and spreads through air, leaf, appliances and other infected pests of mulberry garden, whereas Aspergillosis occurs during chawki stage. White and green muscardine diseases are common in India.

If the infection occurs during spinning, the pupae are mummified which results in high melting % and poor cocoon yield. In case of seed crops, the cocoons become unfit for seed due to high melting % and poor emergence. Different infecting fungi produce different colored spores and accordingly they have been named as.

1) White Muscardine caused by ***Beauvoria bassiana*.**
2) Green Muscardine caused by ***Nomuraea rileyi.***
3) Yellow Muscardine caused by ***Isaria farinosus* .**
4) Black Muscardine by ***Metarrhizuim anisopliae***

8.5.1. White muscardine: The characteristic feature of Muscardine is the mummification of larvae after death by deposition of calcium oxalate salts. Hence, this is also called as "*Calcino*" disease. It is known in India by several vernacular names like "Sunnapukattu" in Andhra Pradesh or "Sunnakattu roga" in Karnataka.

It is the most common fungal disease occurs during rainy and winter seasons under moderate to low temperature and high humidity conditions.

Causal agent: This disease is caused by *Beauveria bassiana*, belongs to the family

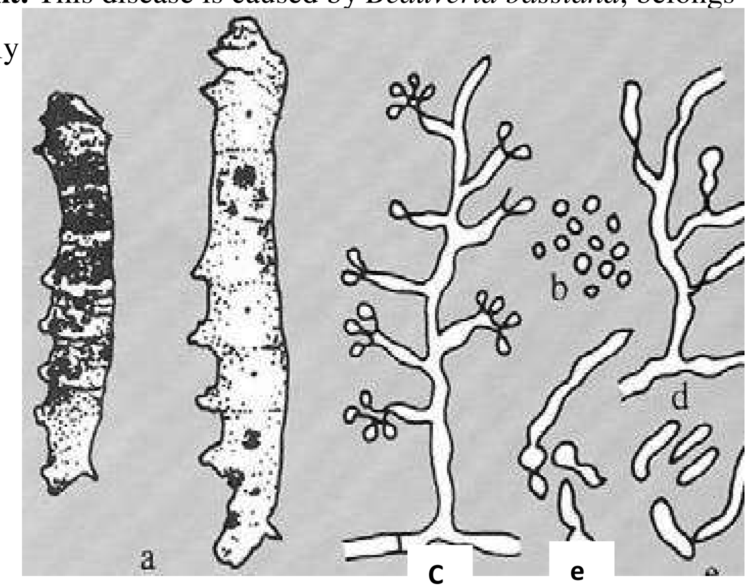


Fig.8.15. Development cycle of *Beauveria bassiana*

(a) Affected larva (b) Conidia
(c) Germination of conidia (d) Formation of cylindrical spores
(e) Cylindrical spores (f) Conidiophore with conidia

Mode of transmission: Infection of Muscardine occurs 90% by penetration through the cuticle, 10% through the spiracles or mouth.

Life cycle of Muscardine

The developmental cycle (Fig. 8.15) of white muscardine consists of three distinct stages namely conidium, vegetative mycelium and aerial mycelium. The conidium is colour less, globular or rarely oval in shape and porcelain white when gathered in a mass. Under favourable conditions of temperature and humidity the conidium germinates within 8 -10 hrs of contact with the body of silkworm. On germination the conidium not only sends out its germ tube but also secretes chitinase which facilitates the germ tube to penetrate the body wall for further multiplication. The germinating tube of conidium after invading the blood of the larvae develops into vegetative hyphae. At the tip of hyphae round or oval shaped short hyphae develops. These often detach themselves and elongate to form vegetative hyphae.

The vegetative hyphae come out of the skin to form aerial hyphae bearing innumerable conidiophores. These conidiophores give rise to small branches which bear one or two conidia. Generally the life cycle of fungus in silkworm varies but normally develops from spore to spore in 10 days in cold weather and about 4 days in hot weather.

Symptoms

- Loss of appetite, inactiveness and lag in growth results 'unequal' in the rearing bed are the early symptoms (Fig. 8.16).
- Moist / oily specks appear on the body mostly around the spiracles or the legs.
- The body of the larvae shrinks and skin becomes inelastic.
- Larvae do not respond to external stimuli and lose spontaneous movement and finally they die.
- Before death, symptoms of diarrhoea and vomiting appear.
- After death, larva becomes soft, within 6 – 8 hrs it becomes stiff and hard.
- Subsequently whole body is covered with conidia except the chitinized parts of the head. Due to deposition of calcium oxalate by the fungus, the dead larva becomes mummified into a chalky white structure.
- In case of infected pupa, they do not respond to external stimuli. The thorax shrinks and abdomen is wrinkled. The conidia grow up to one third of its ordinary weight inside the cocoons, such cocoons sound like dried cocoons when shaken.
- During moth stage the body is hardened and wings fall off easily.

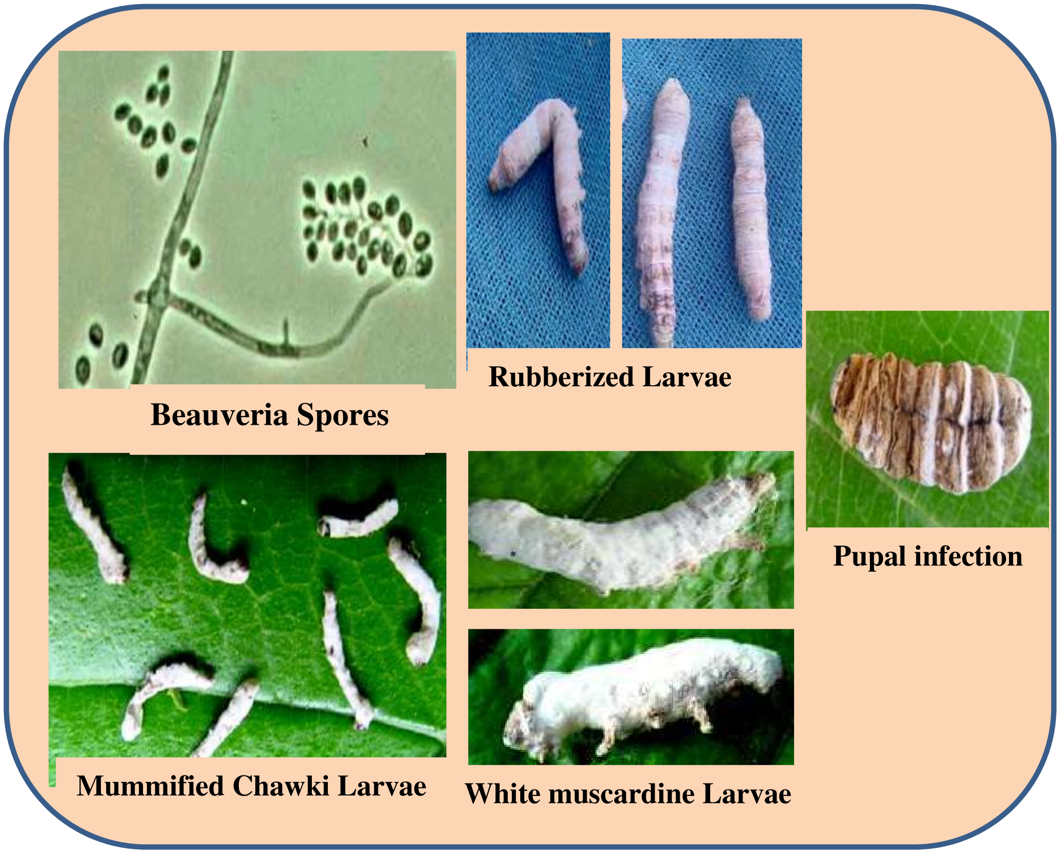


Fig. 8.16. White Muscardine disease symptoms

Prevention and control

1. The rearing house, equipments and surroundings should be properly disinfected before and after each rearing besides maintenance of hygiene during silkworm rearing.
2. Control mulberry pests in the mulberry garden which acts as a secondary source of infection.

3. Pick up diseased larvae before mummification and dispose them by burning
4. Apply bed disinfectants in recommended schedule and quantity.
5. Regulate bed humidity during rainy season by dusting slaked lime powder during moult and even during late age rearing.
6. Maintain optimum temperature and humidity in the rearing house.
7. Good quality mulberry leaf to be provided to the silkworms and provide proper spacing and ventilation during silkworm rearing.
8. Avoid accumulation of left over leaf in rearing beds by regulating the quantum of feedings.
9. Dust dry slaked lime on rearing beds during every moult and apply the same on the floor of the rearing house.
10. **Additional dusting** on 3rd day after 3rd moult and 2nd & 6th day of final stage such as Vijetha supplement or 2% Captof – slaked lime mixture (20 g of Captof in 1 kg of slaked lime) or 2% dithene M-45 – kaolin mixture (20 g Dithane M- 45 powder in 1kg of Kaolin).

8.5.2. Green Muscardine

This fungal disease occurs during autumn and winter season.

A. Causal Agent and Infection

The disease is caused by *Nomuraea rileyi* belongs to family Moniliaceae. Infection occurs through skin by conidia. The conidia germinate in 15-20 hours after infection under favourable condition. The dead mummified larva and infected wild lepidopterous insects are the major source of infection.

The development stages of this pathogen are similar to white muscardine. The conidia are oval and slightly pointed at one end. It is light green, single celled, germinate at 22-24°C in 20 hours. The vegetative mycelium has a germinating tube which elongates to give rise filamentous mycelia with septae. The mucelia produce colourless tubular or bean shaped hyphae. Further hyphae from conidiophores, which are wheel shaped and unbranched. Conidiophores bear a chain of conidia.

Fig. 8.17. Green Muscardine larvae

B. Sympt

No symptoms are seen during early period of disease. But at the later stages dark brown irregular lesions appear on all sides of the body. Sometimes the lesions gather to form large spots with clear circumstance. The larvae show vomiting, diarrhea and finally dies. Then the body slowly hardens and after two or three days, mycelin appear from spiracles and inter segmental regions. After 10 -15 days the mucelia are covered with fresh green conidia (Fig. 8.17)

C. **Prevention and Control**

These are similar to white muscardine.8.5.1.

8.5.3. Aspergillus:

Aspergillus attacks on young age larvae particularly when high temperature and humidity is prevalent.

Causal agent: This is caused by different species of Aspergillus and Stermigmtocytis belonging to the family Monilaceae of class Fungi imperfecta. Silkworms are infected about dozen species of which Aspergillus flavus, Aspergillus oryzae are common.

Life cycle of Aspergillus

The growth stages of the pathogen consist of the conidium, vegetative hyphae and aerial hyphae (Fig. 8.18). The conidium is spherical, 3-4 microns in size. They are resistant to environmental factors and formalin treatment. The favourable temperature for germination of conidia is 30-35° C. Conidia after germination invades the body of the silkworm and develops into vegetative hyphae without the formation of short hyphae and they grow only at the site of invasion. The conidiophore is thick and at distal end expands into a globular or oval structure bearing one to two rows of radiating sterigmata on which conidia are formed.

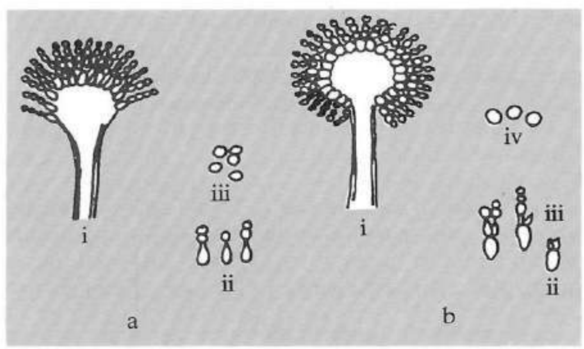


Fig. 8.18. Morphology of Aspergillus Sp.

(a) Aspergillus flavus
(i) Conidiophore
(ii) Sterigma
(iii) Conidia
(iv) Conidia

(b) **Aspergillus oryzae**
(i) Conidiophore
(ii) Phialidae
(iii) Sterigma

Symptoms

- The disease pathogen attacks only on chawki worms (Fig. 8.19.) as it is not strong enough to attack on late age larva.
- Infected larvae stops eating mulberry leaf, becomes lazy, show body tension, restlessness and then die.
- Just before death the head and thorax is extended outwards and vomiting occurs.
- One day after death aerial hyphae appear and later conidia cover the body. The colour depends on the type of pathogen.
- The hardening of corpse in dead larvae is limited to the site of fungus penetration and other parts become black and rotten.

Fig.8.19. Aspergillus infected larvae

Prevention and control

- They are basically similar to white muscardine but main source is through appliances, special care should be taken to bake or sun dry.
- As the silkworm faeces and litter offer a suitable substratum for growth of this fungus, control measures including hygienic management for the pathogen will continuously be importance.
- Remaining all the measures are to be followed as in white muscardine.

8.6. PESTS (Major and minor pests)

Any organism, which interferes with human welfare, leading to economic loss is termed as a pest. With reference to silkworm crop, two important pests are found to cause economic loss. One important and serious pest is uzi fly which causes major damage to crop loss up to 10-20%. In cocoon stage the silkworms are attacked by dermestid beetles. These are commonly referred as carpet beetles. They are reported to cause considerable reduction in egg production in silkworm egg production centers. Some minor pests like straw mite, ants, nematodes, lizards, rats, squirrels and birds also damage to the silkworms and cocoons.

8.6.1. Major Pests: Uzy fly

The Uzi fly, *Exorista bombycis* is a serious endo-larval parasite (pest) of the silkworm causing 10 - 15% loss to cocoon crop in south India. The parasitoid insect belongs to order Diptera and family Tachinidae. This pest incidence is very high in tropical countries like Bangladesh, China, India, Thailand and Vietnam.

Life Cycle of uzifly

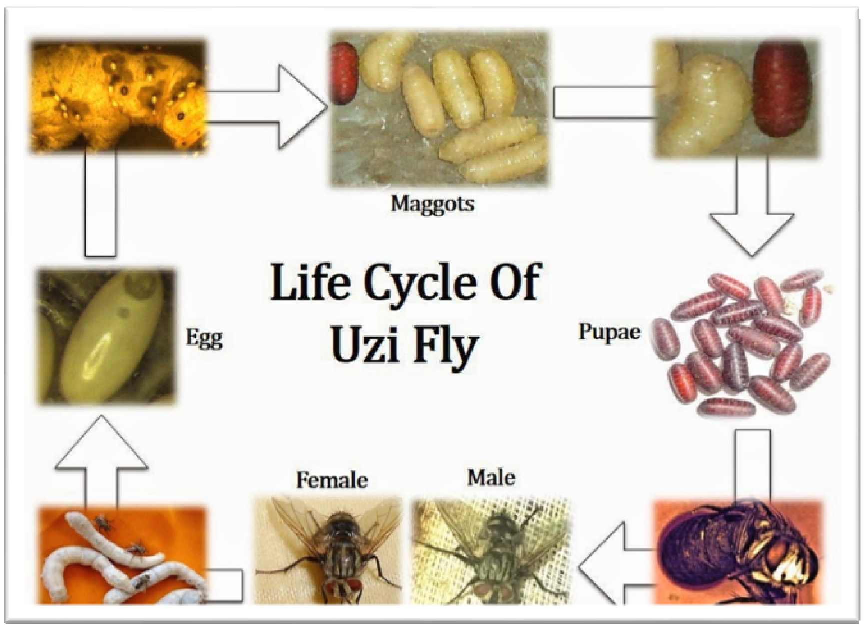


Fig.8.20. Life cycle of uzi fly

(A) Adult

It is blackish gray in colour and distinguishable into head, thorax and abdomen. The head is triangular in shape with conical abdomen. Thorax has four longitudinal black bands on the dorsal side, while the first abdominal segment is black and rest grayish yellow. The life span of adults varies with sex and season. Males survive for about 10 to18 days and females live 2-3 days longer than males. Survival period is long during summer. Sexual dimorphism is very clear in uzy fly. Males are longer (12 mm) than females (10mm). Male has external genitalia covered with brownish orange hairs on the ventral side of the abdominal tip. The bristles on the lateral region of abdomen are denser in male, while they are restricted to last two segments in females.

Egg

The eggs are creamy white measuring 0.45 - 0.56 mm in length and 0.25 - 0.30 mm in width with a long shape. Depending on the environmental conditions the eggs hatch in about 2-5 days after laying. The newly hatched maggot penetrates into the silkworm body.

Maggot

The maggot hatches out through operculum of egg shell which generally faces the silkworm body. The maggot penetrates into the silkworm which is surrounded by a sheath formed by granulocytes and proliferating tissue at the site of the wound. With the growth of maggot the size of the sheath increase and becomes thick and black which finally seen as a black lesion or scar on the silkworm body.

The first and second instar maggots are yellowish white in colour measuring 0.7-1.5 mm and 2.75 mm width and length respectively. The third instar maggots are creamy white measuring 1.3-1.6 cm in length. Maggots have eleven body segments and pass through three instars. The maggot feeds on the body tissues of silkworm and the host dies by the time maggot escapes. The first two instars develop just below the skin but final instar maggots move into the body cavity and grows in size. After 5 - 8 days, the mature maggot escapes by piercing the host integument by its prothoracic hooks.

Pupa

Maggots pupate in about 10-20 hours in the darker area in and around the silkworm rearing house like rearing beds, crevices, corners, below ant wells and rearing stands or in the superficial soil. The body becomes motionless and shrinks before pupation. Pupae are oblong in shape, reddish brown to dark reddish brown in colour, with eleven segments and measures 0.9-1.2 cm in length and 0.4 - 0.6 cm in width. It takes 10 - 12 days to metamorphose into adult which emerges out.

Damages and Symptoms

Uzi infested silkworm larvae up to early fifth instar die before spinning, the larvae attacked in fifth instar, the Uzi maggot comes out by piercing the cocoon (Fig. 8.21 & 8.22). Uzi infected worms are identified by black scar at inter segmental region where the maggot penetrates into the silkworm body. Minute creamy white eggs are observed on the larvae at the initial stage of infestation. Maggot pierced cocoons are unfit for reeling.

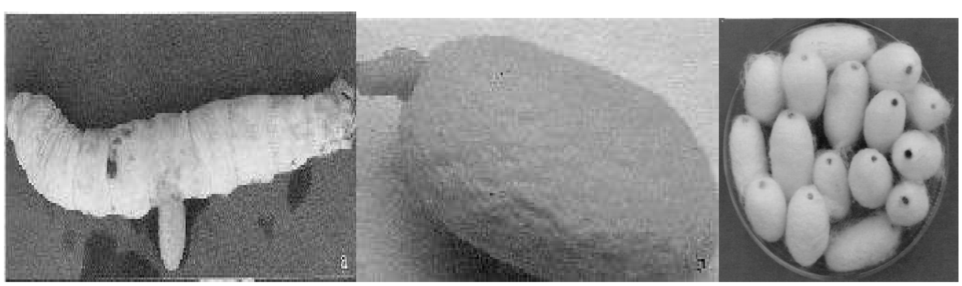


Fig.8.21. Damage caused by uzi at larva, cocoon stages and uzi pierced cocoons

Fig.8.22. Uzi fly on silkworm larvae, uzi egg and its impact on silkworm larvae

Prevention and Control

1. Good sanitary and hygienic conditions in and around rearing room are important.
2. The holes and crevices in the rearing room are to be closed before and during rearing activity.
3. Provide a small anteroom at the entrance of rearing house.
4. Early spinning cocoons which are generally uzi infested, and are to be carefully separated from normal cocoons. These cocoons are stifled to kill the inside maggot (Uzi).
5. Usage of nylon net enclosure to the rearing stand and fixing of wire mesh to windows and doors.
6. Dusting of lavigated china clay on the body of silkworm during mounting prevents oviposition by uzi.
7. Keep uzitrap solution in white trays near doors and windows both inside and outside the rearing house to trap adult uzi fly.

8. Spray / dust the ovicides like uzicide / uzi powder to kill the uzi eggs laid on silkworm body.
9. Collection and destruction of uzi maggots and pupae from rearing house grainage, cocoon market and reeling establishment.
10. Collection and destruction of adult uzi fly.
11. **Biological control method:** Release of natural enemies of uzi fly in the rearing house premises. *Nesolynx thymus*, an ecto-pupal parasitoid to be released @ 2 pouches/100 Dfls on 3rd day of V instar (Fig. 8.23). After mounting of all spinning worms transfer the pouches near chandrikes and after harvesting of cocoons, keep the same pouches near the manure pit. The parasitoids will be emerging continuously for 8 to 10 days.

Fig.8.23. Biological control of uzi fly

8.6.2. Dermestid Beetle *(Dermested Cadverinus)*

Among pests coleopteran insects cause much damage to stored cocoons. These insects are harmful to silkworm directly and sometimes indirectly. Most of the damage is done by the larvae when cocoons are stifled and stored for a long time. The pest larva bores the holes to the cocoons and the pupae are eaten. Besides this, they also damage animal and plant products including leather, furs, dried fish, carpet, woolen and silk materials. These beetles belong to family Dermestidae and prevail throughout the year.

Life Cycle (Fig. 8.24)

1. The female lays 150- 250 eggs in the floss of the cocoon.
2. Eggs hatch within 3 – 6 days.
3. Larval (grub) duration (5 – 7 instars): 28 – 40 days.
4. Pupal duration is about 7 – 8 days.
5. Total life cycle completes in a period of 38 – 54 days.

Fig. 8.24. Dermestid beetle life stages

Damage:

The larva and adults are attracted by the smell of stifled cocoons and the dried pupa inside. They bore into the cocoons and eat the dried pupae and sometimes eggs. Damaged cocoons are unfit for reeling. The pests occur throughout the year causing damage to stored and stifled cocoons. They also damage pierced and melted cocoons which are stored in the grainage building. Presence of cocoon pierced at several places and the egg laying silk moths in the grainages damaged mostly on the abdominal parts are indications of attacks by dermistid beetles (Fig. 8.25).

Fig.8.25. Damage due to Dermistid beetles at cocoon and moth stage

Prevention and Control:

1. The rearing house and cocoon storage rooms should be cleaned periodically.
2. Storage of rejected cocoons for long period should be avoided, wooden equipment are to be dipped in 0.2% Malathion for 2-3 minutes.
3. Provide wire mesh to doors and windows in pierced cocoon storage rooms to avoid free movement of the beetles and grubs from PC storage room to grainage operations room.
4. Collection of beetles physically and destroy them by burning or dipping in soap solution.
5. Storing of pierced cocoons in Deltamethrin treated bags and spraying of 0.028% Deltamethrin solution on walls and floor of PC storage room once in 3 months.
6. Sprinkling commercial grade bleaching powder @200 gm/m2 in the PC (Pierced Cocoon) storage room to prevent migration of grubs from PC storage room.
7. Spray 0.076% DDVP solution on stands and room.

8.6.3. Minor Pests

Besides major pests, there are many minor pests that cause damage to silkworms as well as to cocoons and increase cost of production and crop loses.

8.6.3.1. Mites *(Pediculoides ventricosus)*

This non insect pest belongs to the order Acarina and class Arachind. This mite is encountered at the time of re-thaching of the roof of the silkworm rearing house or brought into the rearing room along with building material such as straw, wood or bamboo. The female mite attacks all the stages of silkworm except eggs, causing death.

Fertilized female gets attached to the suitable host with its claws and suckers. Young larvae and pupae of silkworm are preferred hosts. The mite passes through 17 generations in a year. Each generation time ranges between 7-18 days.

The larvae, pupa and adult silkworm are attacked by this pest. The body surface of a silkworm stuck with this mite develops a few black specks. The purpose of attachment between the host and pest is to obtain nutrition. Further, the pest animal saliva contains toxin which ultimately kills the host. The infested silkworms lose appetite, become inactive and have difficulty in excreting. It takes time to pass the excreta and frequently the excreta are attached bead like to the anus. In severe infestation, silkworms vomit yellowish green fluid and excretes black fluid from the anus.

The skin surface of the attached host bears several rough and uneven black sports. Worms attacked during moult fail to pass the moult and die in a day or two. Infested pupae develop lesions, the body is blackened and they fail to change into adult. In acute attack, silkworms die and within few hours start putrefying. Young silkworms do not putrify rapidly. On identifying attack of acarid pest in the rearing room, the trays should be replaced. All the appliances should be disinfected with steam. Straw (Cotton, Rice) should be kept away from rearing room and appliances.

8.6.3.2. Ants: Ants attack silkworms in the rearing trays, can be prevented by placing the legs of the rearing stands in ant wells. Pouring of little kerosene or keeping kerosene dipped cloth around the legs of rearing stand and chandrika prevents ant crawling.

8.6.3.3. Nematodes: The Nematode *Hexamermis microamphidis* is found in silkworms. This worm attacks the young silkworms and penetrates into the body. The head of the affected silkworm becomes transparent and the body turns milk white.

8.6.3.4. Lizards: These reptiles are seen frequently on the rearing houses. These pests cause serious damage to the rearing by swallowing young silkworms.

8.6.3.5. Rats and Squirrels: These pests eat silkworms, silk gland and the pupa after opening the cocoons. Thus entry of these animals needs to be prevented by arranging suitable wire mesh for doors, windows and ventilators. Rat proof arrangement for the rearing house is to be ensured.

8.6.3.6. Birds: Crows, sparrows pick up the silkworms when the mountages are kept our doors at the time of spinning. The damage caused by these birds can be avoided by indoor rearing.

8.7. Integrated Disease and Pest Management (IDPM)

Incidence of diseases and pests is a serious concern in silk production due to prevailing tropical condition. Annual crop loss due to diseases during silkworm rearing varies between 15 to 20% in National level. The incidence of pests and diseases in silkworm rearing is very common and sometimes lead to complete crop loss. The mulberry silkworm is affected by a number of insect pests like uzifly (*Exorista bombycis* Louis), earwig, dermistid beetles and ants. Among the pests, uzifly is the most serious pest in Karnataka and Andhra

Pradesh.

Of late it is practically proved than an integrated approach involving both chemical and biological methods is more effective than individual methods for the control of pests and diseases. Such methods have gained importance in all agriculture related sectors. Studies revealed that instead of depending exclusively on chemical and pesticides, an emphasis on an integrated approach in silkworm disease and pest management in sericulture sector is quite useful.

To overcome the problem of diseases and pest attack during rearing, implementation of combined efforts for preventive and control measures is termed as integrated disease and pest management (IDPM). Most of the diseases are common during rainy and winter season cause annual crop loss of 20%. At the same time the damage caused by major and minor pests of silkworm during rearing and spinning also should be considered to reduce the crop loss. For combined control of all diseases and pests integrated disease and pest management must be followed. Silkworm rearing house, its utility rooms, corridor, mounting hall and the surrounding, rearing appliances etc., needs to be disinfected once immediately after completion and before the commencement of the rearing. The predisposing factors responsible for occurance of silkworm diseases such as constitution of the silkworm, nutriotional status, crowding, pathogen load and environmental factors. No individual preventive measure is sufficient to check the disease incidence and pest management and hence an integration of several innovative measures has been developed for the management of silkworm diseases and pests. Different aspects of integrated disease and pest management are as follows.

Disinfection: It means the selective elimination of undesirable micro-organisms. In sericulture it is the destruction or inactivation of disease causing germs. In sericulture, the commonly used disinfectants are formaldehyde, chlorine compounds, paraformaldehyde, slaked lime powder, etc. Bed disinfectants such as labex, vijetha, Shakthi etc. are used. Disinfection is the single most important aspect of integrated disease management. In addition to different pathogens, environmental and nutritional factors also plays a significant role towards susceptibility of the host to infection and development of diseases.

Under integrated disease management, due importance towards strict adherence to maintenance of optimum environmental and hygienic conditions in and around the rearing house is a prerequisite for a successful cocoon harvest. The important hygienic conditions summarized as follows.

- Clean the rearing house and appliances of dust and dirt with water five days before brushing.
- Sprinkle 5% bleaching powder in slaked lime surrounding the rearing house once in 2-3 days.
- Avoid injury to diseased larvae.
- After bed cleaning, wipe the floor with 2% bleaching powder in 0.3% slaked lime.
- Provide optimum bed space and keep the bed dry.
- Before entering into the rearing house, disinfect the hands by washing in 2% bleaching powder solution in 0.3% slaked lime.
- Disinfect the feet by walk over 5% bleaching powder in slaked lime on a foot mat at the entrance of rearing room.
- Pick up disease and unsized or suspected diseased worms before bed cleaning and dispose them into 5% bleaching powder in a basin.
- Pick the diseased or dead larvae and flimsy cocoons from the mountage and burnt them.

Location of rearing house: Under Integrated Disease Management, having a separate rearing house to provide optimum conditions and for preventing and controlling the diseases helps to minimize the crop loss. Orientation of the room should such that the interior is protected from the direct sunlight, as it is harmful to worms. The rearing building may be oriented in East – West direction to reduce the impact of radiation and the room should be with proper ventilation. The optimum environmental conditions during silkworm rearing needs to be provided and ensured for integrated disease management. As the separate rearing house facilitates the silkworms for conducive atmosphere which inturn helps to obtain successful crops. In addition, rearing management also shows prime importance in preventing the silkworms from diseases and to obtain higher yields in sericulture.

Rearing management:

- Bed cleaning should be done with proper mesh size of net as per the stage. Recommended bed cleaning is once in 1st instar and twice in 2nd instar and from 3rd stage daily in the morning hours under tray rearing method.
- Under shoot rearing method based on the bed condition, it is recommended to do bed cleaning once in 4th instar and once in 5th instar, if required.
- When 90% of the larvae settled for moulting, no feeding to be given to worms. Slaked lime to be dusted to reduce bed humidity. Rearing bed maintained as thin to reduce bed humidity.
- The selection of silkworm breed / hybrids also stands very prominent under integrated disease management. Hence under favourable seasons, rearing of bivoltine hybrids and cross breeds under unfavourable seasons is recommended.

- Choice of mulberry variety for silkworm rearing is very important for harvesting successful crop. The mulberry leaf is the exclusive food of the silkworm, and it is essential that mulberry leaves are good and of suitable quality for the silkworm. Leaf quality is the major contributor for the successful rearing and under integrated disease management.
- The harvesting of leaf should be done during cooler hours of the day. The leaves should be properly preserved in leaf chamber, covered with wet gunny cloth. The leaf moisture could be retained by spraying water over the leaf at frequent intervals during summer.
- Most of the silkworm diseases are season specific and hence forewarning system of disease should be there for effective and timely management of diseases.
- Incidence of different diseases in silkworm may be due to various sources of secondary contaminations including alternate sources of secondary contaminations including alternate hosts in and around mulberry garden. It is essential to control mulberry pests not only to increase the yield and quality of mulberry but also to prevent silkworm diseases.

- Mass mother moth examination method for the production of disease free layings at Commercial Seed Production Centers.
- Rearing late age silkworm on shoot rearing method.
- Specific disease management measures for summer season
- The common diseases during summer are Grasserie and Flacherie. Maintenance of optimum temperature and relative humidity and good ventilation in the rearing house was suggested to avoid disease incidence.
- Recommended for fixing of wet gunny cloth screens to windows

and doors during summer season.

- An additional disinfection of rearing house and appliances with 0.3 % slaked lime is also suggested.
- Specific disease management measures for winter and rainy seasons.

The successful harvest of cocoons in silkworm rearing may be attributed to efficacy of the disease management technology. The practice of technology through selection of silkworm rearing house for effective disinfection, use of suitable disinfectant and use of bed disinfectant and hygiene maintenance helps in avoiding infection of silkworm and the spread of diseases. The system of chawki certification for disease freeness helped in initiating specific management practices.

The effective implementation of Silkworm Disease Management Technology coupled with the potential of the popular bivoltine hybrids are exploited to the fullest extent by ensuring disease free rearing. The stability in terms of productivity and silkworm larval health was achieved which mean successful elimination of risk factor in silkworm rearing. As the risk factor was addressed successfully, the sericulturists become confident and have adopted the technology and were also enthused to adopt highly productive and remunerative bivoltine sericulture which not only improves quantity of silk per unit area but also improves the financial status of the farmers.

For the first disinfection 2% bleaching powder (stock powder having above 30% chlorine) in 0.3% slaked lime solution and the second disinfection 2% formalin or 500 ppm chlorine dioxide in 0.5% slaked lime solution. Additional disinfection before the second disinfection should be performed by using 0.3 - 0.5% slaked lime solution in extreme cases where grassarie and flacherie were observed during previous crop. The disinfection solution should be prepared freshly and to be used @ 2 lt/sq. m floor area.

Each disease could be prevented with its own strategy such as for the prevention of Nuclear Polyhedrosis caused by *Bm*NPV and *Bm*IFVis possible through complete disinfection and using of disease tolerant breeds. In case of *Bm*DNV could be prevented by using complete disinfection and use of disease resistance breeds. Bacterial and fungal diseases could be prevented by complete disinfection and through effective rearing management. Further, the Pebrine is prevented by complete disinfection and through seed crop monitoring. It is suggested that the diseases could be controlled or minimized by means of integration of various approaches (Table 8.1).

Table. 8.1 Strategies on hand for management of silkworm diseases

√ = Ensure the strategy

Strategy	*Bm*NPV	*Bm*IFV	*Bm*DNV	Bacterial	Fungal	Pebrine
Complete disinfection	√	√	√	√	√	√
Rearing condition				√	√	
Resistant Breeds	Use of Disease tolerant breeds					
Seed crop monitoring						√

Integrated Pest Management: Care should be taken to control all major and minor pests. For controling Uzi fly all the windows and doors should be fitted with wire mesh which also controls the entry of other minor pests. Uzicide can also be sprayed especially on 4 – 5th age larvae. Lavigated china clay dusting prevents uzi infestation during spinning. Rearing house should be rat proof, ant wells are placed below all the legs of rearing stands. Dusting of bleaching powder around the rearing house also prevents the entry of ants and other pests. During silkworm rearing the maintenance of optimum temperature and humidity is more important, any fluctuations leads to outbreak of different disease causing pathogens. Along with optimum conditions regular sprayings and dustings of different disinfectants should be followed as a preventive measure.

Prevention is better than cure is the correct approach and that should be adopted in integrated disease and pest control. This means that one should go about actively preventing disease before it occurs, and it is only when preventive measures are in force that we can hope to effectively control the occurrence and spread of diseases. Further all the precautionary measure need to be under taken parallel to restrict the pest attack during silkworm rearing. Various control measures have been adopted by farmers to control uzi fly. Although these measures help to reduce uzi infestation, the economic loss is not completely avoided. This is only possible when the farmer is aware of all these diseases and pests to minimize reduce and control for ensuring the crop success in silkworm rearing for harvesting higher yields.

The Uzi fly, *Exorista bombycis* is a severe endo larval parasitoid of the silkworm and it causes considerable loss to sericulture industry and it has to be controlled by means of all the possible approaches such as physical, chemical and biological approaches. Among the different management practices used, cultural methods such as exclusion, *i.e.*

fixation of fly-proof wire mesh screens to the windows, ventilators and doors of rearing rooms and securing fly proof nylon net to individual trays, are found to be the most eco-friendly and economical. The usage of hyper parasitoids, chemicals, quarantine measures etc. in integrated manner could minimize the pest incidence.

Exclusion Method

- Provide wire mesh/nylon net on all windows/doors.
- Provide doors with automatic closing mechanism.
- Provide anteroom at the entrance of the rearing house.

Physical (Uzi trap)

- Dissolve one tablet in 1 litre of water and keep the solution in white trays both inside and outside the rearing house at window base from 3rd instar onwards. The flies are attracted to its colour and fall into the solution.

Biological

- Release Nesolynx thymus (an ecto- pupal parasitoid of the uzi fly) inside rearing house on 3rd day of V instar.
- After mounting of all spinning worms transfer the same pouches near the chandrikes.
- After harvesting of cocoons keep the same pouches near the manure pit and two pouches are required for 100 dfls.

Rearing Management:

i) **Trapping of uzi fly**: Place uzi trap inside the rearing house on the entire window base (till the removal of rearing residue) to trap the uzi flies entering inside the rearing house till rearing residue is removed. Also, keep the door in closed condition which will prevent the uzi flies escaping from the rearing house and further multiplication.

ii) **Packing of silkworm litter**: Most of the uzi fly maggots do pupate in silkworm rearing bed itself, as no cleaning of bed is practiced in shoot system. Therefore, after the completion of the rearing, it is suggested to separate the silkworm litter from the mulberry twigs in rearing bed and pack it immediately in plastic bags and keep outside the rearing house at least for 15 days. This will ensure destruction of all the maggots, pupae and emerged flies available in the litter. From 100 DFLs rearing, 8 to 10 bags of residue is expected and later the same can be utilized for composting.

iii) **Proper disposal of flimsy cocoons**: Flimsy cocoons should be burnt. Otherwise, they should be kept separately in a container so that uzi maggots, if any, coming out from them can be collected and destroyed. In addition to all the above, certain other measures also could be practiced to minimize the uzi menace in silkworm rearing.

1. Uzi flies if noticed inside the nylon net should be immediately killed. Hand picking of uzi fly infected worms and emerging maggots in rearing tray and killing them in formalin or hot water solution.
2. Making the floor of the rearing room free from cracks and crevices is suggested so that the parasite maggots will not get a suitable place for pupation.
3. Maggots falling from mountages should be collected and destroyed.
4. In the cocoon markets, the crawling maggots should be collected and killed by dropping them in hot water or formalin solution. The cocoons of infested lots should be stifled in the cocoon market itself, soon after purchase, so that the maggots are killed.

Summary

- *The silkworms are infected by various microorganisms such as Protozoa, Bacteria, Virus and Fungi.*
- *Pebrine disease shows symptoms in all stages of silkworm.*
- *Pebrinized eggs shows overlapped few numbers of eggs with insufficient glue for adhesion.*
- *The bacterial diseases of silkworms are collectively called as Flacherie. They are of Septicemia, Bacterial diseases of digestive organs and Bacterial toxicosis.*
- *In Septicemia the bacteria multiply in haemolymph of larva, shows beaded like faeces apart from the general symptoms.*
- *In case of Bacterial diseases of digestive organs swelling and transparency of head is seen and this disease is also called as 'transparent head diseases'.*
- *Sotto or toxicosis because of bacteria bacillus releases endotoxin, which causes convolutions and tremors in larva.*
- *Viral diseases are classified with the presence of inclusion bodies as Inclusion and Non-inclusion type which includes nuclear polyhedrosis and Cytoplasmic polyhedrosis (NPV & CPV).*
- *Infectious flacherie is caused by Morator virus.The diagnose of infection is concluded with flouroscent antibody technique.*
- *Gattine is primarly invaded by virus and secondarily by bacteria Streptococcus, which produces histopathological lesions in the intestinal epithelium.*
- *Muscardine appear in various forms and depending upon the colour of spores they are called white, green, black and yellow muscardine.*
- *White muscardine is caused by Beaveria bassiana which is common and prevalent. It shows inelasticityofskin, stops movement and finallydie.*
- *There are some major and minor pests which damage the silkworm crop.All these can be controlled by adopting simple preventive precautionary measures during rearing activity.*

Short answer questions

1. What is the causal organism of pebrine disease?
2. Write the symptoms of pebrinized eggs.
3. How pebrine is detected in silkworm.
4. What are the causal agents of N.P.V and C.P.V ?
5. How sotto disease is identified?
6. Name the causative organism of sotto disease.
7. Draw a neat sketch of structure of pebrine spore.
8. Name the causal organism of muscardine and aspergillus.
9. What is the other name of Gattine and why is it so?
10. Name the major pests of silkworm.
11. Name the minor pests of silkworm.
12. Write the scientific name of Uzy fly with classification.
13. What is the damage caused by Dermestid beetle?
14. How biological control is done in Uzy fly?
15. Write the scientific name of Beetles?

Long answer type questions

1. Explain symptoms of Pebrine disease at various stages of silkworm.
2. Write briefly on symptoms of bacterial diseases.
3. Give an account on Grasserie disease of silkworm.
4. Write in detail about the Cytoplasmic polyhedrosis?
5. Describe the symptoms of Muscardine on silkworm larva with preventive and control measures.
6. Explain the life cycle of Uzy fly.
7. Write about the integrated pest management of uzy fly?
8. Brief an account on minor pests seen in rearing.
9. Write in detail about the integrated disease management.
10. Write in detail about the damage that causes to silkworm by uzi fly and its control measures.

SERICULTURE I YEAR

PART B VOCATIONAL SUBJECTS

PAPER – I MULBERRY CULTIVATION

BLUE PRINT

PERIODS/WEEK: 04 **PERIODS/YEAR: 135**

S.No	NAME OF THE UNIT	No. of Periods	Weightage marks -	Short answer questions	Essay questions
1	**History of Sericulture**	5	2	1	-
2	**Morphology and Taxonomy of Mulberry**	25	16	2	2
3	**Non-mulberry food plants**	15	8	1	1
4	**Soils and Preparation of Land**	20	10	1	1
5	**Mulberry planting methods: Introduction**	20	8	1	2
6	**Mulberry Cultivation**	20	8	1	1
7	**Manures & Fertilizers**	20	8	2	1
8	**Nutritive values of Mulberry leaf**	10	8	1	1
	Total	135	68	10	8

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SERICULTURE I YEAR

PART B –VOCATIONAL SUBJECTS

PAPER –II

SILKWORM REARING REQUIREMENTS AND MANAGEMENT

BLUE PRINT

PERIODS/WEEK: 04 PERIODS/YEAR:135

S.No	NAME OF THE UNIT	No. of Periods	Weightage marks -	Short answer questions	Essay questions
1	**Non- Mulberry Silk Worms**	15	8	1	1
2	**Rearing House**	15	10	2	1
3	**Rearing Equipment**	15	8	1	1
4	**Preparation for Rearing**	15	8	1	1
5	**Environmental Conditions and Management**	15	8	1	1
6	**Economics of Silkworm rearing**	20	12	2	1
7	**Entrepreneurship Development**	20	6	1	1
8	**EDP in Sericulture**	20	8	1	1
	Total	135	68	10	8

SERICULTURE **I YEAR**

PART B –VOCATIONAL SUBJECTS

PAPER - III **SILKWORM REARING TECHNOLOGY**

BLUE PRINT

PERIODS/WEEK: 04

PERIODS/YEAR : 135

S.No	NAME OF THE UNIT	No. of Periods	Weightage marks -	Short answer questions	Essay questions
1	**Hatching and Brushing**	15	8	1	1
2	**Chawki Rearing**	20	16	2	2
3	**Late age Rearing –**	15	8	1	1
4	**Spinning and Mounting**	15	8	1	1
5	**Effective Rate of Rearing**	10	10	2	1
6	**Bivoltine Rearing Technology**	15	8	1	1
7	**Silkworm Anatomy**	15	8	-	1
8	**Silkworm Diseases and Pest management –I**	30	8	2	1
	Total	135	68	10	8

MODEL QUESTION PAPER

SERICULTURE

I Year

Paper – I MULBERRY CULTIVATION

Time : 3 Hours **Max. Marks: 50**

SECTION-A

Note: (i) Answer all the Questions (ii) Each Question carries 2 marks **10X2=20**

1. What is Silk Road?
2. Write the classification of Mulberry.
3. Mention any four best and new varieties of mulberry.
4. Mention food plants Tasar and Eri silkworms.
5. What is Acidic soil Reclamation?
6. What is sapling?
7. Name any four garden implements.
8. Mention importance of organic manures?
9. NPK
10. Mention mulberry leaf contents?

Section-B

Note: (i) Answer any five Questions (ii) Each Question carries 6 marks **5X6=30**

11. Describe the morphology of mulberry plant.
12. Explain different Hybrid varieties of mulberry grown in India..
13. Explain different types of soils in Andhra Pradesh.
14. Explain about different planting methods and advantages of tree plantation
15. Explain Bud grafting methods in mulberry plant.
16. Write different types of weeds in mulberry and their control methods.
17. Briefly explain the preparation of vermi-compost.
18. Write short notes on

a) Bye products of mulberry b) Drip irrigation c) soil mulching

MODEL QUESTION PAPER

SERICULTURE

I Year

Paper – II SILKWORM REARING REQUIREMENTS AND MANAGEMENT

Time: 3 Hours **Max. Marks: 50**

Section-A

Note: (i) Answer all the Questions (ii) Each Question carries 2 marks 10X2=20

1. Write the Scientific names of Eri and Muga Silkworms.
2. Name any two rearing houses in India.
3. Orientation of rearing house?
4. Draw diagrams of any two rearing equipments.
5. What is Disinfection?
6.Mention required optimum conditions required for late age rearing
7.What is CRC?
8. Bed waste utilization.
9. Subsidies given for silkworm rearing
10. What is EDP?

Section-B

Note: (i) Answer any five Questions (ii) Each Question carries 6 marks 5X6=30

11. Describe salient feature of Tassar Silkworm.
12. Draw labelled diagram CSB Mdel rearig house.
13. Write advantages of mechanization on large scale Sericulture
14. Write different disinfection methods adopted in rearing silkworm.
15. Explain Environmental conditions required in silkworm rearing.
16. Write economics for maintaining 300DFLs shoot rearing.
17.Write an essay on self employment opportunities in Sericulture sector.
18. Write Short Notes on
a) Kissan nurseries b) commercial CRCs c) Licensed seed producers (LSPs)

MODEL QUESTION PAPER

SERICULTURE

I Year

Paper – III SILKWORM REARING TECHNOLOGY

Time: 3 Hours **Max. Marks: 50**

Section-A

Note: (i) Answer all the Questions (ii) Each Question carries 2 marks 10X2=20

1. What is 'Black boxing' of Eggs?
2. Leaf Preservation
3. What is Moulting?
4. Bed cleaning.
5. What is mounting?
6. Define Leaf Cocoon Ratio (LCR)
7. Name any two bivoltine commercial breeds
8. Formula ERR calculation
9. Pebrine disease symptoms in egg stage.
10. Name any two minor pests.

Section-B

Note: (i) Answer any five Questions (ii) Each Question carries 6 marks 5X6=30
(iii) Draw neat diagrams where ever necessary.

11. Explain about the methods of brushing.
12. What is bed cleaning? Explain its methods.
13. Explain about chawki rearing methods.
14. Explain in detail about shoot rearing.
15. Explain in detail about different types of mountages.
16. Explain about Bivoltine rearing and its importance.
17. Explain about white muscardine disease and suggest control measures.
18. Write Short Notes on

a) Uzi fly life cycle b) Biological control c) NPV