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SERICULTURE

SECOND YEAR

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Intermediate Vocational Course

Paper I : Seri – Biotechnology & Farm Management

Paper II : Silkworm Seed Technology

Paper III : Post Cocoon Technology

STATE INSTITUTE OF VOCATIONAL EDUCATION

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Text Book Development Committee

Paper -I SERI – BIOTECHNOLOGY & FARM MANAGEMENT

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SERICULTURE

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SERICULTURE

Paper – I

Seri – Biotechnology & Farm Management

INDEX

UNIT 1

Seri-Biotechnology

Structure

Learning objectives

After studying this chapter, the students will be able to know;

- The importance of biotechnology in relation to sericulture.
- The various branches and scope of biotechnology
- The techniques of tissue culture and its importance in sericulture.
- The importance of Silkworm and mulberry breeding.
- The various laboratory equipments used in biotechnology laboratory
- The various sericulture R & D institutes available in India

1.1. Introduction

Biotechnology, often shortened as biotech, is the area of biology that uses living processes, organisms or systems to manufacture products or technology intended to improve the quality of human life known as **Biotechnology. Biotechnology simply means 'the scientific art of using living organisms to make desired goods'. It deals with integral applications of Microbiology, Biochemistry, Plant sciences, animal sciences and process engineering techniques in manufacturing and service industries.**

Biotechnology is the youngest branch of biology. It was first recognized as a separate branch of Leeds City Council in the United Kingdom in 1920. However, the name biotechnology has come into wide use after 1970s. Although biotechnology is considered to be of recent origin, the basic fermentation process effected by years has been known since long back. Only the scientific knowledge of fermentation has developed recently in the recent era. In fact, biotechnology began when humans started to plant their own crops, domesticate animals, ferment juice into wine, make cheese, and leaven bread. So it is generally believed that biotechnology as a whole is not at all a new branch rather it is an ever growing and needful area of science for the welfare of human beings.

The European Federation of Biotechnology (1978) defined biotechnology as "the integral application of knowledge and techniques of chemistry, microbiology, genetics and chemical engineering to draw benefits at the technological level from the properties and capacities of microorganisms and cell cultures.

The term Biotechnology indicates the product of interaction between science and technology. The discovery of biotechnology dates back to 1920 when Chaim Weizmann converted starch into butanol and acetone; the latter was an essential component of explosives during World war-I. During World war II Alexander Fleming (1929) produced penicillin from cultures of ***Pencilium notatum*****.** The third rediscovery of biotechnology is about recombinant DNA technology.

1.2. Biotechnology and its branches

Biotechnology has adopted techniques of biological sciences, chemistry, physics, mathematics and computer science and hence it is not a independent branch. On the basis of technology is being used, it is divided as the following disciplines.

1. **Tissue culture Technology:** It deals with the culture of cells or tissues of plants and animals in chemically defined media.
2. **Pharmaceutical Technology:** It is concerned with the production of monoclonal antibodies, interferons, vaccines, toxioids, human growth harmones, etc.
3. **Recombinant DNA technology:** It deals with the insertion of desired genes into host cells for manipulating the host DNA.
4. **Agriculture Biotechnology:** It includes all technologies of crop improvement and the application of biofertilizers and selective biocides in agriculture.
5. **Food Biotechnology:** It is concerned with preparation, preservation and utilization of various food items.
6. **Fermentation Technology:** It deals with culture of cells or microbes in fermenters to produce alcohols, biogas, organic acids, enzymes, antibiotics, etc.
7. **Mining and Metal biotechnology: It deals with** waste recycling, compost making and microbial treatment of pollutants which are otherwise non-biodegradable.
8. **Environmental Biotechnology:** It deals with waste recycling, compost making and microbial treatment of pollutants which are otherwise non-biodegradable.
9. **Industrial Biotechnology:** It deals with the industrial production of desired goods.

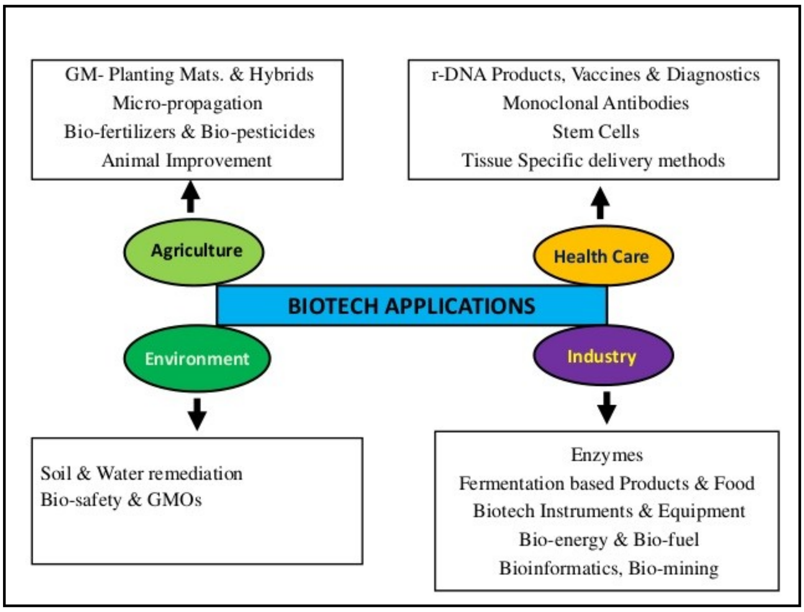


Fig. 1.1. Application of biotechnology in various sectors

1.3. Scope of Biotechnology: Biotechnology basically aims at improving the quality of life and at protecting him from dangerous diseases. Biotechnology is being entrusted mainly for the following purposes.

a. To produce more food for the growing population using the available land.
b. To develop disease resistant and high yielding varieties
c. To introduce biofertilizers instead of chemical fertilizers
d. To introduce biocides in agriculture
e. To preserve germplasm of plants, animals and microbes
f. To produce pharmaceutical products to treat severe diseases in man and animals
g. To produce biofuels for reducing the felling of forest trees for fuel wood.
h. To minimize hazards of pollution
i. To make use of various microorganisms in food packing and preservation of the food.
j. To withstand devastating plant pests, such as insects, weeds and diseases, and help him plow and spray his fields less.

1.4. Plant bio-technology

"Plant biotechnology describes a precise process in which scientific techniques are used to develop useful and beneficial plants''. Every living thing contains a genetic "blueprint" or set of instructions to determine specific characteristics. In plants, this blueprint helps determine a food's specific traits, including color, taste and texture. For hundreds of years, humans have improved plants by breeding for certain traits. Even the ancient Egyptians and early American Indians selected and sowed the seeds from plants with desired characteristics, combining them with other desired qualities to attain the best results. While effective, this traditional approach to plant breeding involves the random crossing of hundreds of thousands of genes to get the desired traits in a new plant—a process that can be costly and time consuming.

Today, researchers can achieve the same kind of genetic exchange through biotechnology, but with greater precision and efficiency. New plants with desirable traits can be developed and will offer traits not possible through the traditional breeding process. The current biotech crops, as well as those in various stages of development, can improve farm income and reduce pesticide usage even further. Biotechnology also has the potential to deliver more nutritious, plentiful and potentially lifesaving foods. For example, tomatoes with more cancer-fighting antioxidants and oil seeds that produce oils with lower saturated fat content are in development. "Golden" rice also promises to provide children in developing countries with added beta-carotene to control vitamin A deficiency, which causes blindness and even death. For centuries, farmers have worked carefully to improve the food and fiber they grow. Biotechnology offers a more precise and efficient ways to develop plants that will help feed and clothe a growing world population with reduced pesticide.

This branch of science is aimed to conduct cell culture, tissue culture for mutant selection in relation to crop improvement. Further production of secondary metabolites *i.e.* alkaloids, glucosides (steroids and phenolics), terpenoids and a variety of flavours, perfumes, agro-chemicals are also produced. The yield of these chemicals in cell culture is though generally lower than in whole plants. It can be substantially increased by manipulating under physiological and biochemical conditions.

Other techniques like micro propagation, synthetic seeds, production of virus free plants, maintenance of male sterile parents for hybrids, propagation of hybrid plants, overcoming crossing barriers, endosperm culture, production of haploids and to use in plant breeding programmes, isolation of protoplast and culturing, regeneration of plants. Gene transfer methods, transgenic plant propagation for crop improvement, molecular farming, targeting of foreign proteins into mitochondria, molecular mapping of plant genomes, isolation and purification of different enzymes for medical and clinical food industry and many other industrial uses. Protein engineering, metabolic engineering for over production of metabolites and for use of microbes in industry and agriculture are the aspects of plant biotechnology practices in the present days with an aim to develop various industries for mankind.

1.5. Seri-biotechnology

The recent advances in Biotechnology *viz*. recombinant DNA techniques, genetic engineering through manipulation of desirable traits, stem cell research etc., has revolutionized research in plant and animal sciences. However, the impact of Biotechnology is yet to find a significant place in Sericulture. Japan, China and India, the largest producers of natural silk in the world, have invariable made a few attempts but sincere attempts to introduce biotechnology in sericulture is now being taken up.

In recent years, silkworm has become a model organism for understanding the biology of silkworms to manipulate and reconstruct the genes to produce high quality silk. Some of the significant findings include sex linked markers, characterization of DNA markers, construction of early linkage maps, establishment of stable germ line transformation, production of pharmaceutically important proteins, immune response proteins and annotation of thousands of expressed sequence tags (ESTs), construction of Bacterial Artificial Chromosome libraries (BACs), identification and characterization of Z chromosome linked genes, accomplishment of whole genome sequencing, identification of W chromosome specific BACs, Lepidoptera specific genes, horizontal gene transfer and characterization of essential baculo viral genes.

The development and improvement of protocol of silkworm transgenesis has opened new areas of application. The nuclear polyhedro virus is also being exploited as a vector for introduction of foreign genes. Expression of marker proteins (luciferase and green fluorescent protein) has been successfully achieved in cell lines and larval caterpillars of silkworm (*Bombyx mori*) employing recombinant *Bm* NPV vector harboring reporter genes.

Andhra Pradesh State Sericulture Research and Development Institute (APSSRDI), Hindupur has developed transgenic silkworm hybrids in association with *Centre for DNA Fingerprinting and Diagnostics* (*CDFD*), Hyderabad. Such an attempt for the development of transgenic silkworm hybrids was initially carried out with Transgenic silkworm strains expressing multiple essential viral genes (ie1, ief1, ief3 and P74) in an inverted repeat manner under Actin promoter, using a technique of *piggyBac* mediated germline transgenesis. The transgenic lines generated under Nistari genetic background showed stable resistance against the virus and this antiviral property was transferred then to a high yielding commercial silkworms.

Mulberry leaf is soul food for Mulberry silkworm *Bombyx mori* (L), the nutritive value of a Mulberry leaf has its influence on the growth and development of Silkworm *Bombyx mori* (L). Attempts are being made *i.e.* breeding, hybridization, tissue culture for the production of nutritive Mulberry leaf. Mulberry is an important plant in Sericulture industry as the foliage constitutes the chief feed for the Mulberry silkworm *Bombyx mori* (L). The silkworm *Bombyx mori* (L) is a monophagus insect feeds only on the Mulberry leaves. The growth, development, yield, quality and disease resistance in silk worms are mainly depend on nutritive values of the leaf.

Sugars and Proteins are major elements responsible for the silkworm growth, development and silk production. The silkworm utilizes sugars (Carbohydrates) as source of energy for the synthesis of lipids and amino acids emphasized that among 20 tested sugars. Sucrose strongly stimulated the feeding behavior followed by Fructose and Raffinose. Nutritional value of proteins is very important as silkworm larvae utilize the leaf nitrogenous matter for their growth and development and synthesis of silk protein.

Keeping the importance of seri-biotechnology, Central silk board (CSB), Govt. of India has established Seri biotech Research Laboratory (SBRL) at Bangalore, as an R & D institute during 1993 for conducting research in frontier areas of modern biology and to seek potential applications of this work to improve silk productivity.

India is yet to reap the benefits of Seri-biotechnology to bring out products in the form of technology as the same is still in infant stage in spite of making sincere but compartmentalized attempts. In view of this status, focus has to be entrusted on developing technologies targeted at improvement of silkworm and host plants. With respect to improvement of silkworm needs to emphasize on the major diseases, their epidemiology for early detection of pathogens, pathogenicity and pattern of host resistance as well as its impact on “post cocoon traits such as denier, filament length, uniformity, tensile strength etc”. The improvement of silkworm should be based on short listing of available silkworm germplasm races for various improved economic traits through detection of respective DNA markers. Similarly, in case of improvement of host plants the focus should include tolerance to biotic and abiotic stresses as well as developing transgenic mulberry through introgression of genes for stress tolerance and silkworm disease resistance. It is hoped that recent developments in silkworm genome research provides ample opportunities to silkworm geneticists and breeders to perform such an important task.

1.6. Tissue Culture

Plant cell and tissue cultures are also used for the production of primary and secondary metabolites. They are also used for germplasm storage. For the first time, tissue culture method was developed by G. Haberlandt in 1902. He is often called the father of plant tissue culture. He did not use growth harmones in the culture medium. F. Skoog and C.O. Miller (1975) demonstrated the importance of growth harmones in plant tissue culture.

1.6.1. Plant tissue culture

The culture of plant cells or plant tissues in a synthetic culture medium under controlled aseptic conditions is known as tissue culture. It is also called invitro culture. The culture medium provides all minerals and growth hormones necessary for the growing cells. The controlled conditions give the culture a suitable microenvironment for the cell growth. The in vitro culture of plant cells or tissues in artificial medium is said to be plant tissue culture.

1.6.1.1. Application of plant tissue culture:

It has many applications in crop improvement, preservation, breeding and in industries which are as follows.

a. Micropropagation
b. Elimination of pathogen from plant materials
c. Germplasm storage
d. Embryo rescue
e. Production of haploids
f. Production of artificial seeds
g. Production of secondary metabolites
h. Production of somatic hybrids
i. Production of transgenic plants

1.6.2. Animal tissue culture

The rearing of animal cells or tissues in a chemically defined medium under controlled conditions is called animal tissue culture. It is also called in vitro culture of animal cells. Animal tissue culture is employed in the study of the following.

a. Cell structures
b. Cell nutrition and cell cycles
c. Cellular metabolism
d. Oncogenesis
e. Production of animal viruses
f. Production of antiviral compounds
g. Production of therapeutic proteins
h. Embryo development

1.6.2.1. Applications of Animal tissue culture

Animal tissue culture is an important tool in modern biology. It has been put into many practical uses relating to human welfare. The important uses of animal tissue cultures are as follows.

1. **Organ culture:** It refers to an organ or parts of the organ in vitro from appropriate tissue. The whole organ cannot be grown in vitro as it is made up of different types of cells. The parts of the organ consisting of identical cells can be made by tissue culture.

2. **Production of vaccines:** Animal cell cultures are used to propagate viruses to make vaccines. The virus is allowed to infect animal cell cultures. The virus multiplies and produces numerous virus particles in the cells. The mature virus particles come out of the animal cells by breaking their cell membranes. The mature culture is treated with a hypertonic solution to lyse the cells. The lysate is centrifuged to remove the cell debris. The supernatant is filtered through a high quality filter to get virus particles for vaccination.

3. **Somatic cell fusion:** The method of fusing two different cell types is called somatic cell fusion or somatic hybridization. The fusion product is called somatic hybrid.

4. **Genetic Engineering:** In genetic engineering, recombinant viruses are constructed and allowed to infect eggs or zygotes growing in a nutrient medium. After reaching certain globular stage, the embryo is implanted into the uterus of a female. Thus the female gives birth to transgenic individuals.

5. **Sperm Bank:** It is a collection of semen from farm animals, fishes, oysters or man stored in liquid nitrogen. It supplies semen timely when and where it is in need.

6. **In vitro fertilization:** The process of fertilizing an egg with a sperm in a nutrient medium in the culture plate is known as in vitro fertilization. This method is practiced in farm animals and women having damaged fallopian tubes. It overcomes the difficulties in fertilization in such individuals.

1.6.3. Role of Tissue Culture

Conventionally Mulberry is propagated by seedlings, cuttings, saplings and root grafts. Perennial nature of the plant coupled with prolonged juvenile period limits the speed of the improvement in the crop. Further, dioecious nature of the genus in which the important species are represented by one sex only (either male or female), which is a barrier to genetic improvement by conventional hybridization technique. There is a paucity of information about the inheritance pattern of yield contributing characters which is a limiting factor in choosing the parents. Moreover in vegetatively propagated plants like Mulberry takes many years to evolve a desirable clone from economical and commercial point of view by conventional hybridization methods.

In- vitro techniques such as tissue and organ culture offer the plant breeder new openings in the colonel propagation, genetic manipulation and production of homozygous inbred lines to improve the nutritive value in Mulberry leaves. Cellular totipotency nature is the base for tissue culture technique.

Tissue culture broadly refers to the *in-vitro* culture of plants, seeds and plant parts (tissue organs, embryo single cell protoplast etc.,) on nutrient media under aseptic conditions. Principle of tissue culture is totipotency of plant cell which means the ability of an individual cell to express the phenotype of the whole plant from which it is derived in the nutrient media under aseptic conditions. Tissue culture is thus proving to be useful in a variety of ways including plant propagation raising and maintenance of high health status plants, germplasm maintenance and a valuable techniques in plant improvement.

1.6.4. Tissue and Organ Culture

Tissue and organ culture is the process to grow cells, tissues and organs in an artificial medium. It is conducted in vitro process. In this method a plant part is taken and introduced into glass equipment in aseptic condition into a suitable nutrient medium after sterilization. Every tissue, organ or any plant part requires a proper medium. The mediums are specific to different species depending on the requirements of nutrients. Many propagating medium possess inorganic salts, vitamins, sucrose, auxins, gibberellins, cytokinins, food stuffs and growth regulators in different quantities. These are mixed as per the plant requirements. This culturing has nutrient medium, aseptic condition and air circulation phases.

1.7. Tissue Culture in Mulberry

1.7.1. Nutrient medium

It is called basic medium having sugar, inorganic substances, and vitamins. When plant material is kept on this medium an undifferentiated cell mass callus develops. The auxins present in medium induce root system and cytokinins induce stem system. These materials are dissolved in distilled water to mix them in medium. Coconut milk, fruit juices and yeast are mixed with medium for vitamins and hormones, otherwise commercial products available in the market can also be used. The P^H must be 5.8. The medium is made semi solid by adding 1% agar. This method of medium preparation was described by Murashi and skoog

1.7.2. Aseptic condition

The nutrient medium is favorable for various micro-organism to undergo proliferation, thus aseptic condition is necessary. The medium is transferred into glass equipment and kept in autoclave of 120^{o}c temperature, 30 pounds pressure for 15 min and then plugged with sterilized cotton. The tissue of plant organs are surface sterilized by 0.5 percent sodium hypochloride or mercury chloride. The medium is kept in inoculation chamber and plant material is introduced into the medium.

1.7.3. Aeration

It can be done by keeping the tissue on the surface of semi solid nutrient medium.

1.7.4. Process of culturing

The basic medium is prepared with sucrose, inorganic substances, and vitamins. The NAA, NBA are added to get Auxins and kinetin or cytokinins. To make it semi solid medium one percent agar is added and made aseptic. Plant parts are surface sterilized to introduce into nutrient medium and kept in air conditioned chamber. Callus develops in four weeks which will be transferred into a plastic pot. A separate medium is prepared for this purpose. The pot is kept at $20\text{-}25^{0}$c for two more weeks and later can be transplanted in shade and later in the field.

Importance of Tissue Culture

a. Large number of plants produced in a short period and best method to develop rare and scarce plants.
b. Any plant part can be developed into a plant.
c. Pest resistant varieties can be produced by taking plant tissues material from virus infested plant.
d. Disease resistant hybrids can also be produced.
e. Seed fertility can be known by reducing dormancy.

1.8. Importance of mulberry breeding

1. The object of mulberry improvement under tropical conditions is to evolve a variety which gives maximum leaf yield of good quality throughout the year by making use of the abundant solar energy available throughout the year.
2. The variety must have a quick regeneration capacity and faster growth so as to produce a large amount of biomass and variations.
3. The strain must produce thick succulent unlobed leaves.
4. Leaves must be high in moisture content and retain the moisture for longer period after harvest. .
5. The variety must be amicable to vegetative propagation through cuttings with good sprouting and rooting ability.
6. Strains must show good responses to repeated pruning and other agronomical practices.
7. It must show resistance to moisture stress, pests and diseases.
8. As sericulture economics depends on cocoon produced in an unit area over a unit time, higher mulberry leaf yield per unit area is a key factor.

Over the years, conventional breeding has made considerable achievements in mulberry by developing varieties with high leaf yield, wider adaptability, better leaf quality, and suitable to specific cultural practices. Nonetheless, due to high heterozygosity and out breeding reproductive system, genetics of mulberry remains an enigma to the breeders. Lack of adequate information on the genetics and breeding behaviour of important traits makes mulberry breeding quite uncertain. Recent advancements in biological tools and techniques have armed the geneticists and breeders with new tools to tackle some of the unruly problems. Characterization of germplasm by molecular markers enables the selection of parents with wider genetic differences and desirable traits. DNA markers tightly associated with desirable traits are handy for earlier identification of hybrids with desirable gene combinations. Genetic engineering is another potential tool that can be used for mulberry genetic improvement. Thus, concerted efforts are to be made to integrate conventional breeding with advanced technological developments to accelerate varietal development in mulberry for better sustainability and profitability of the silk industry in India.

1.9. Importance of silkworm breeding

Silkworm breeding is aimed at the overall improvement of silkworm from a commercial point of view depending upon the natural and socio-economic situation of the country. Breeding mainly emphasizes the improvement in the expression of several quantitative traits in silkworm. The major objectives are improving fecundity (the egg-laying capacity of a breed), the health of larvae, quantity of cocoon and silk production, and disease resistance. Healthy larvae lead to a healthy cocoon crop. Health is dependent on factors such as better pupation rate, fewer dead larvae in the mountage, shorter larval duration (shorter larval duration lessens the chance of infection) and bluish-tinged fifth instar larvae (which are healthier than the reddish-brown ones). Quantity of cocoon and silk produced are directly related to the pupation rate and larval weight. Healthier larvae have greater pupation rates and cocoon weights. Quality of cocoon and silk depends on a number of factors including genetics. As such, silkworm breeding aims to achieve better performance of several components of which fecundity, cocoon / raw silk yield, cocoon / raw silk quality, cocoon crop stability and other specialized traits are prime importance. In addition to the usual process of breeding for high yield and good quality, health and robustness, the other breeding aims are as follows.

1. Specific physical properties related to size and other quality control characteristics of silk filament.
2. Development of the silkworm hybrid that can be reared throughout year *i.e.* for biotic and abiotic stress.
3. Development of the breeds with special characters.
4. Capability to have polyphagous feeding habits by accepting low cost artificial diets or taking foliage other than mulberry.

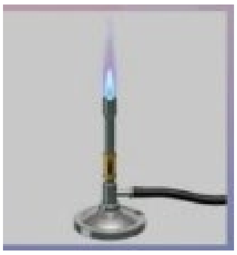
5. Ability to resist or tolerate diseases including adverse environmental conditions.
6. Development of some behavioral traits more suitable in rearing and handling, including mechanization of cocoon production.

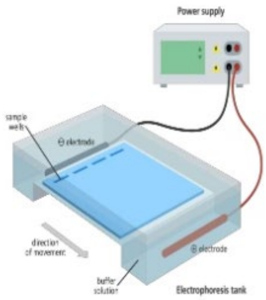
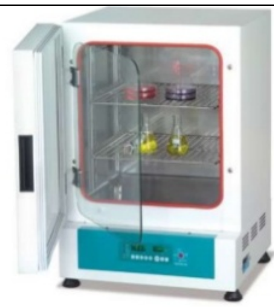
1.10. Laboratory equipment used in Biotechnological experiments

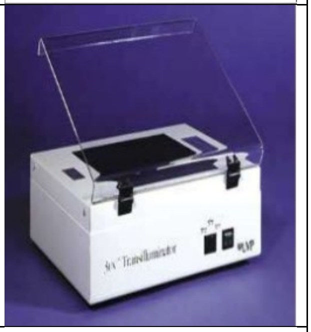
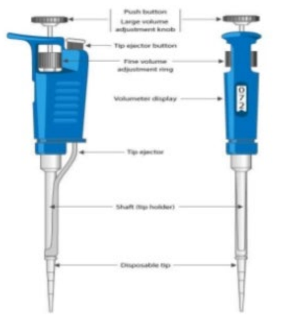
The branch of biotechnology, as a very relevant field of applied biology, has got deeply integrated with the domain of different disciplines. The field involves use of living organisms and bioprocesses for manufacturing products that are benefiting to human; it can be manufacturing of medicine, tissue culture, genetic engineering, etc. Hence, in the domain of biotechnology extensive research and development processes are conducted upon, which demand better apparatus and instrument. In light of this, providing a wide range of biotech lab equipments are used for a variety of purposes. Some of biotechnology instruments are Centrifuge, Incubator, Shaking Incubator, Growth Chambers, Constant Temperature & Humidity Chamber, Water Bath, Circulation Water Bath, Autoclave, Auto Steam Sterilizer, UV Sterilizer, Drying Oven, Vacuum Oven, Multishaker, Vortex Mixer, Twister, Rocker, Rotary Drum Mixer, Bio Hazard Safety Cabinet, Flake Type Ice Maker, Cold Lab Chamber, etc. Some of the important instruments / items used in biotech laboratory are listed in the Table 1.1.

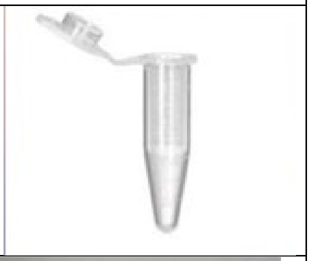
Table 1.1. Laboratory Equipment and Glassware used in biotechnology

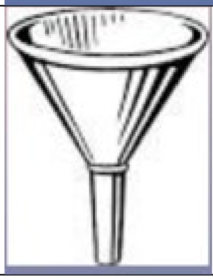
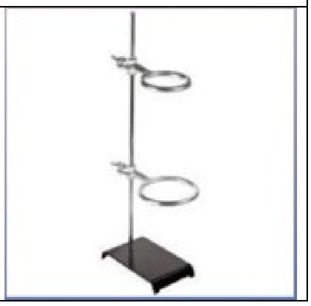
Sl. No.	Name of the item / equipment	Usage	Image
1	Autoclave	A heated and pressurized container used to sterilize equipment and kill any living organism left.	
2	Water bath	Keeps items up to a specific temperature and keeps it at that temperature.	
3	Hot plate	An electrical device used to heat things up.	
4	Compound Light microscope	An instrument used to see things not visible to the naked eye.	
5	Incubator	An apparatus used to control the environment to culture and grow bacteria and hatching eggs artificially or to provide stable environment for a reaction.	

Sl. No.	Name of the item / equipment	Usage	Image
6	Micropipette	It is used to measure exact amount of small amount of liquids.	
7	Centrifuge	An apparatus consists essentially of compartment spun at high speed to help separate liquids from solids.	
8	Electronic balance	Used to measure small amounts weight.	
9	Bunsen Burner	A natural gas powered piece of equipment that is used to heat, sterilization or combustion.	
10	Thermometers	Used to measure temperature	
11	Laminar airflow chamber	Used to prevent contamination of semiconductors, biological samples or any particle sensitive device.	

12	Electrophoresis chamber	A Chamber used in gel electrophoresis that conducts an electrical current.	
13	Distiller	It is used to mix or agitate solutions.	
14	Electrophoresis chamber	Separation and analysis of macromolecules (DNA, RNA, Proteins) and their fragments based on their size and charge.	
15	Thermal cycler (PCR machine / DNA amplifier)	Most commonly used to amplify segments of DNA via the polymerase chain reaction (PCR)	
16	Ultra low temperate freezers	For long term storage of biological samples like DNA / RNA, Proteins, cell extracts or reagents	
17	Incubators	It is used to grow and maintain microbiological cultures with optimum conditions.	

18	Spectrophoto-meter	To measure the concentration of the solution	
19	UV translluminator	It is used to view DNA/ RNA that has been separated by electrophoresis through an agarose gel.	
20	Air displacement micropipetts	It is a type of adjustable micropipette that delivers measured volume of liquid.	
21	Forceps	It is used to grip objects that are too small for your fingers to hold or to hold extremely hot items.	

Sl. No.	Name of the item / equipment	Usage	Image
22	Graduated Cylinder	Used to measure liquid volume with accuracy.	
23	Petri dish	Holds specimens for observation and growth cultures.	
24	Microcentrifuge tubes / eppendroff tube	Used to hold small measures of liquids to be used in a centrifuge.	
25	Pestle and Mortar	Used to crush the items and mix solids.	
26	Beaker	Used to heat, stir and measure liquids.	

Sl. No.	Name of the item / equipment	Usage	Image
27	Dropper Pipetes	Used to measure small amounts of liquid for transfer	
28	Test Tube	Used to hold, heat and mix small amounts of solids or liquids.	
29	Funnel	Used to channel liquids without spillage.	
30	Storage container	Used to hold and store chemicals and other solids / liquids with proper labels.	
31	Ring stand	Used to hot beakers and other items that are being heated.	

1.11. Sericulture Research and Development Institutes in India

India has emerged today as the second largest producer of mulberry raw silk besides being producing all the varieties of commercially exploited silks of the world. Such an achievement was made possible as a result of significant breakthrough made in Research and Development in tropical sericulture. R&D support is the back bone of any industry for quality improvement and higher returns with the help of new technologies.

The Central Silk Board (CSB) is a Statutory Body, established during 1948, by an Act of Parliament (Act No.LXI of 1948). It functions under the administrative control of the Ministry of Textiles, Government of India, having head quarter at Bangalore. The Board comprises 39 members appointed as per the powers and provisions of the CSB Act 1948, for a period of 3 years.

In order to co-ordinate the sericulture development programmes in different states & for undertaking pre-shipment inspection of silk goods meant for exports, the Central Silk Board has established 10 Regional Offices at New Delhi, Mumbai, Kolkata, Jammu, Hyderabad, Chennai, Bhubaneshwar, Guwahati, Lucknow, Patna and 3 Certification Centers at Bangalore, Varanasi & Srinagar. Regional Offices of CSB maintain a close liaison with the State Sericulture Departments, field units and CSB field functionaries to co-ordinate transfer of technology. Regional Offices are also conveners of State Level Sericulture Coordination Committee meetings constituted by the Central Silk Board.

The mandated activities of CSB are Research and Development, maintenance of four tier silkworm seed production network, leadership role in commercial silkworm seed production, standardizing and instilling quality parameters in the various production processes and advising the Government on all matters concerning sericulture and silk industry. These mandated activities of Central Silk Board are being carried out by the 297 units of CSB located in different States through a integrated Central Sector Scheme *viz* "Integrated Scheme for development of sericulture Industry" with the following 4 components.

1. Research & Development, Training, Transfer of Technology and I.T. initiatives.
2. Seed Organization,
3. Coordination and Market Development.
4. Quality Certification Systems, Export, Brand Promotion & Technology Up-gradation.

1.11.1. Research institutes under Central Silk Board, Govt. of India

The main Research & Training Institutes of the CSB provide scientific and technological support for enhancing production and productivity for sustainable sericulture through innovative approaches. The Central Sericultural Research and Training institute (CSR&TI), located at Mysore (Karnataka), Berhampore (West Bengal) and Pampore (J & K) to deal with Mulberry sericulture. Whereas Central Tasar Research and Training institute located at Ranchi (Jharkhand) deals with Tasar sector and Central Muga, Eri Research and Training institute located at Lahdoigarh, Jorhat (Assam) deals with Muga and Eri sector (Table 1.3).

Table. 1.3. Research institutes under central Silk Board

Sl. No.	Name of the institution	Located at	Deals with
1	Central Sericultural Research and Training institute (CSR&TI)	Mysore, Karnataka	Mulberry sector
2		Berhampore West Bengal	
3		Pampore, Jammu & Kashmir	
4	Central Tasar Research and Training Institute (CTR&TI)	Ranchi, Jharkhand	Tasar Sector
5	Central Muga Eri Research & Training Institute (CMER&TI)	Lahdoigarh, Assam	Muga and Eri sector
6	Central Silk Technological Research Institute (CSTRI)	Bangalore	Post cocoon sector
7	Silkworm Seed Technology Laboratory (SSTL)	Bangalore	Seed sector
8	Central Sericultural Germplasm Resource Centre	Hosur, Tamilnadu	Germplasm station
9	Seribiotech Research Laboratory	Bangalore	Seri biotechnology

Regional Sericulture Research Stations (RSRS/RTRS/RMRS) for Mulberry and Vanya sericulture have been functioning for the development of region specific technology package and dissemination of research findings as per regional needs. The RSRS for mulberry research are located in Chamrajnagar (for rainfed mulberry) and Bangalore (for irrigated mulberry) in Karnataka, Salem and Coonoor (Tamil Nadu), Anantapur (Andhra Pradesh), Trivandrum (Kerala), Kalimpong (West Bengal), Ranchi (Jharkhand), Dehradun (Uttar Pradesh), Jorhat (Assam), Dhule (Maharashtra), Koraput (Orissa) and Pampore (Jammu). There are six regional research stations for tasar sericulture and one for muga sericulture. Besides, a network of Research Extension Centre (RECs) & its sub units for mulberry and vanya silk are also functioning to provide extension support to sericulturists. In order to provide R & D support in post cocoon sector, the Board has established a Central Silk Technological Research Institute (CSTRI) at Bangalore. In addition, the CSB has also set up Silkworm Seed Technology Laboratory (SSTL) in Bangalore (Karnataka), Central Sericultural Germplasm Resource Centre (CSGRC) at Hosur (Tamil Nadu) and Seri-Biotech Research Laboratory (SBRL) at Bangalore.

1.11.2. Andhra Pradesh State Sericulture Research and Development Institute (APSSRDI): It was established during 1995 under the World Bank assisted National Sericulture Project. The Institute is located at Kirikera, Hindupur in Anantapur district of Andhra Pradesh. The institute is working with a vision to make sericulture accepted as a sustainable economic activity contributing to overall development of the industry through innovative and creative scientific excellence. The man date of the institute is as follows.

- To conduct research in the frontier areas of polyvoltine and bivoltine silkworm breeding with an aim to develop productive and qualitatively superior silkworm breeds/hybrids.
- To conduct research for development of robust silkworm hybrids to cater different regions and seasons of Andhra Pradesh.
- To develop silkworm disease prevention and control measures.
- To transfer silkworm breeds and the technologies developed by the institute to the users through Department of Sericulture.
- To train the Sericulture Department Staff and farmers in silkworm rearing and advanced sericulture technologies.
- To survey and collect season-wise incidence of pebrine disease in silkworm and to suggest control measures to Department of Sericulture.
- To conduct seminars, group discussions, demonstrations and field shows etc. for the effective transfer of technologies to the users.

1.11.3. Karnataka State Sericulture Research & Development Institute (KSSRDI): It is a pioneer State Research Institute established by Government of Karnataka during the year 1982 to provide Technical solution for the development of Sericulture. It works in close association with Department of Sericulture conducting need based research and developmental activities. The main station is located in Bangalore and it is well equipped with multi disciplinary research laboratories and experienced Scientists. The Institute has four sub stations for different agro climatic regions at B.R.Hills and Ooty which serve as silkworm germplasm stations and Melinakuruvalli, Shimoga District and Kadaganchi, Gulbarga district. The core mandate of this Institute is to carry out Research & Development, Training, Extension and finding solutions to the technical problems of sericulture industry.

Apart from the central and state research institutes, the agricultural universities such as University of Mysore, Mysore, Gandhi Krishi Vignana Kendra (GKVK), Bangalore, Tamil Nadu Agricultural University (TNAU), Coimbatore, Tamil Nadu etc. are also conducting research in the area of sericulture for the overall development of sericulture in the country.

Summary

Biotechnology, often abbreviated as biotech and it is the youngest and emerging branch of biology. It is the area of biology that uses living processes, organisms or systems to manufacture products or technology intended to improve the quality of human life. ***The biotechnology simply means 'the scientific art of using living organisms to make desired goods for the welfare of*** *human beings is known as* ***Biotechnology.' It deals with integral applications of Microbiology, Biochemistry, Plant sciences, animal sciences and process engineering techniques in manufacturing and service industries.***

It is also mentioned about the branches of biotechnology and scope of biotechnology. *Basically the branch aims at improving the quality of human life and protecting them from dangerous diseases. The application of biotechnology with reference to plant is known as plant biotechnology. It describes a precise process in which scientific techniques are used to develop useful and beneficial plants''. The researchers can achieve the kind of genetic exchange through biotechnology, but with greater precision and efficiency. New plants with desirable traits can be developed and will offer traits not possible through the traditional breeding process. The current biotech crops, as well as those in various stages of development, can improve farm income and reduce pesticide usage even*

further. Biotechnology also has the potential to deliver more nutritious, plentiful and potentially lifesaving foods. This branch of science is aimed to conduct cell culture, tissue culture for mutant selection in relation to crop improvement.

With reference to biotechnological progress in silkworm and mulberry discussed in the current chapter. Further it is to note that, in recent years, silkworm has become a model organism for understanding the biology of silkworms to manipulate and reconstruct the genes to produce high quality silk.

The importance of tissue culture has been studied with reference to plant tissue culture and animal tissue culture and its applications in respective areas through tissue culture. It is to note that the culture of plant cells or plant tissues in a synthetic culture medium under controlled aseptic conditions is known as plant tissue culture and it is also called invitro culture. The rearing of animal cells or tissues in a chemically defined medium under controlled conditions is called animal tissue culture. It is also called in vitro culture of animal cells.

In the present scenario continuous development of silkworm breeds / hybrids and its host plant, mulberry is necessary to improve the productivity in sericulture. To achieve progress, the importance of silkworm breeding and mulberry breeding has been discussed. Integration of biotechnology and breeding methods is necessary to have highly productive and disease resistant breeds with better accuracy and in less time.

The branch of biotechnology, as a very relevant field of applied biology, has got deeply integrated with the domain of different disciplines. The field involves use of living organisms and bioprocesses for manufacturing products that are benefiting to human; it can be manufacturing of medicine, tissue culture, genetic engineering, etc. Hence, in the domain of biotechnology extensive research and development processes are conducted upon, which demand better apparatus and instrument. In light of this, providing a wide range of biotech lab equipments, which are used for a variety of purposes has been discussed.

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 possible as a result of significant breakthrough made in Research and Development in *tropical sericulture. R&D support is the back bone of any industry for quality improvement and higher returns with the help of new technologies. In light of the above, in the present chapter various Sericulture Research and Development Institutes in India role and their mandate has been discussed particularly special reference to Central Silk Board (CSB), Andhra Pradesh State Sericulture Research and Development Institute (APSSRDI) and Karnataka State Sericulture Research and Development Institute (KSSRDI) and various other universities.*

QUESTIONS

I. Short questions.

1. Define Biotechnology?
2. Mention some secondary metabolites?
3. Define tissue culture?
4. What is plant tissue culture?
5. What is animal tissue culture?
6. Mention any two applications of plant biotechnology?
7. Mention any two applications of animal biotechnology?
8. Write any few points about the importance of mulberry breeding?
9. Write any few points about the importance of Silkworm breeding?
10. Define culture medium.
11. Name some of the R & D institutes in sericulture?
12. Name any five equipments used in biotechnology laboratory?

II. Essay Questions.

1. Write about the plant tissue culture and its application?
2. Write about the scope of biotechnology
3. Explain about the seri-biotechnology?
4. Write in detail about various R & D institutes involved in sericulture in India?
5. Write the importance of mulberry and silkworm breeding?
6. What is tissue culture? Write about the culture medium and application of plant tissue culture?
7. What is biotechnology? Write about various branches of biotechnology?
8. Write in detail about the application of animal tissue culture?
9. Write about the laboratory equipment used in biotechnology laboratory?

Ψ

UNIT 2

Cytology and Anatomy of Mulberry

Structure

Learning Objectives

After studying this chapter, the students will be able to know;

- The importance of cell in the living organisms
- Different type of cells, structure and their functions
- Difference between the prokaryotic and eukaryotic cell.
- Different types of cell divisions in plants.
- Significance of mitosis and meiosi cell divisions.
- Functions of Gene and DNA structure
- Mendal laws and reasons for Mendal's success.
- Anatomy of root, stem and leaf of mulberry

2.1. INTRODUCTION: All organisms are composed of cells and some are made up of a single cell and these are called unicellular organisms while others composed of many cells are called multi-cellular organisms. Cells are the smallest form of life; the functional and structural units of all living beings. The cell, derived from Latin '*cella'*, meaning "small room" is the basic structural, functional and biological unit of all living organisms. Cells are often called the "building blocks of life". The study of cells is called *Cell biology*.

Cells consist of cytoplasm enclosed within a membrane which contains many bio-molecules such as proteins and nucleic acids. Organisms can be classified as unicellular (consisting of a single cell; including bacteria) or multicellular (including plants and animals). While the number of cells in plants and animals varies from species to species, humans contain more than 10 trillion (10^{13}) cells. Most plant and animal cells are visible only under a microscope, with dimensions between 1 and 100 micrometres.

The term cell was first coined by an Englishman, Robert Hooke in the year 1665. He observed compartment like structures in the section of bottle cork, named them as "CELLS", basic units of life. In 1674 Leeuwenhoek, a Dutch lens grinder observed free living cells for the first time. In 1824, Dutrocht stated that all living organisms are composed of cells. The cells are classified into two – prokaryotic cell and eukaryotic cell based on the presence or absence of true nucleus in the cell. The eukaryotic cells which contain a nucleus, and prokaryotic, which do not have a nucleus. Further, the Prokaryotes are single-celled organisms, while eukaryotes can be either single-celled or multicellular.

2.2. Prokaryotic cell Vs. Eukaryotic cell

Prokaryotes are unicellular in nature, as they possess a single cell like bacteria and archaea while few single cell and all multicellular organisms are known as Eukaryotes. The universal organelles such as ribosomes, cytoskeleton and plasma membrane are present both in prokaryote or eukaryotic cells. The organelles which present only in eukaryote cells either in plant or animal are the nucleus, Endoplasmic Reticulum, Golgi apparatus, Mitochondria and centrosome where as the organelles such as Chloroplast, vacuole and cell wall are present in plant cell only. The lysosomes are present only in animal cell.

Prokaryotic cell: They are simpler and smaller. A prokaryotic cell doesn't possess nucleus or other cell organelles. It is derived from a Greek word meaning before nuclei. They are reproduced through nuclear fission. It has a capsule which covers the outside of the wall, a cell wall which provides strength and rigidity, cytoplasm helping in cellular growth and a plasma membrane containing proteins, etc. The cytoplasm region contains ribosomes which are the smallest part and play a vital role in protein synthesis, mesosomes or the folding that help in cellular respirations, plasmids the small circle of DNA, pili, and flagella.

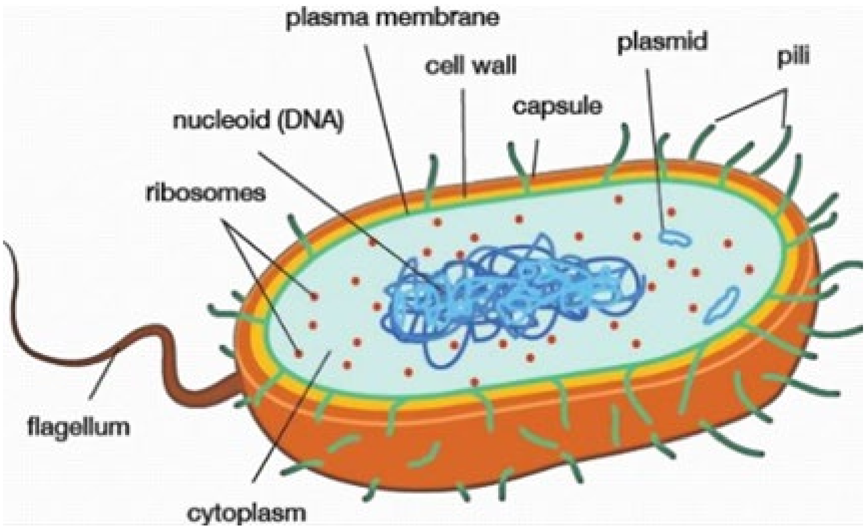


Fig. 2. 1. Structure of Prokaryotic cell

Prokaryotes include bacteria and archaea, two of the three domains of life. Archaea constitute a domain of single-celled microorganisms. These microbes (**archaea**; singular **archaeon**) are prokaryotes, meaning they have no cell nucleus. Prokaryotic cells were the first form of life on Earth, characterized by having vital biological processes including cell signaling. They are simpler and smaller than eukaryotic cells, and lack membrane-bound organelles such as a nucleus. The DNA of a prokaryotic cell consists of a single chromosome that is in direct contact with the cytoplasm. The nuclear region in the cytoplasm is called the nucleoid. Most prokaryotes are the smallest of all organisms ranging from 0.5 to 2.0 µm in diameter.

All prokaryotes have a cell wall surrounding the cell membrane. The fluid matrix filling the cell is the cytoplasm. Enclosing the cell is the cell envelope – It generally consists of a plasma membrane covered by a cell wall which, for some bacteria, may be further covered by a third layer called a capsule. Though most prokaryotes have both a cell membrane and a cell wall. The envelope gives rigidity to the cell and separates the interior of the cell from its environment, serving as a protective filter. Inside the cell is the cytoplasmic region that contains the genome (DNA), ribosomes and various sorts of inclusions. The genetic material is freely found in the cytoplasm. Prokaryotes can carry extra chromosomal DNA elements called plasmids, which are usually circular. The plasmid DNA confers certain unique phenotypic characters to such bacteria, one such character is resistance to antibiotics. On the outside, flagella and pili project from the cell's surface. These are structures (not present in all prokaryotes) made of proteins that facilitate movement and communication between cells.

Prokaryotic cells are fundamentally different in their internal organization from eukaryotic cells. Notably, prokaryotic cells lack a nucleus and membranous organelles. Prokaryotic cells have the following features:

1. The genetic material (DNA) is localized to a region called the nucleoid which has no surrounding membrane.
2. The cell contains large numbers of ribosomes that are used for protein synthesis.
3. At the periphery of the cell is the plasma membrane. In some prokaryotes the plasma membrane folds in to form structures called mesosomes, the function of which is not clearly understood.
4. Outside the plasma membrane of most prokaryotes is a fairly rigid wall which gives the organism its shape. The walls of bacteria consist of peptidoglycans. Sometimes there is also an outer capsule. It is to be noted that the cell wall of prokaryotes differs chemically from the eukaryotic cell wall of plant cells and of protists.
5. Some bacteria have flagella which are used for locomotion and/or pili, which may be used to pull two cells in close contact, and perhaps to facilitate the transfer of genetic material.

Eukaryotic cell: It is complex and larger than the prokaryotic cells. It is also derived from a Greek word which means true nuclei. These include all the protists, plants, animals and fungi. They include all life kingdoms except monera. In eukaryotic cells there is an extensive compartmentalization of cytoplasm through the presence of membrane bound organelles. Eukaryotic cells posses an organized nucleus and a nuclear envelop. In addition, eukaryotic cells have a variety of complex locomotory and cytoskeletal structures. They consist of the cell wall which protects and supports the plasma membrane, the plasma membrane surrounds the cell and controls the entry and exit of certain substances, the nucleus containing DNA that stores all information, nuclear membrane surrounds the nucleus, nucleolus playing a vital role in protein synthesis, mitochondria are involved in performing their cellular functions, chloroplast being the subcellular sites of photosynthesis, endoplasmic reticulum helping in movement of materials, ribosome composed of proteins, Golgi bodies, lysosomes, vacuoles, cytoplasm, chromosomes, and centrosomes.

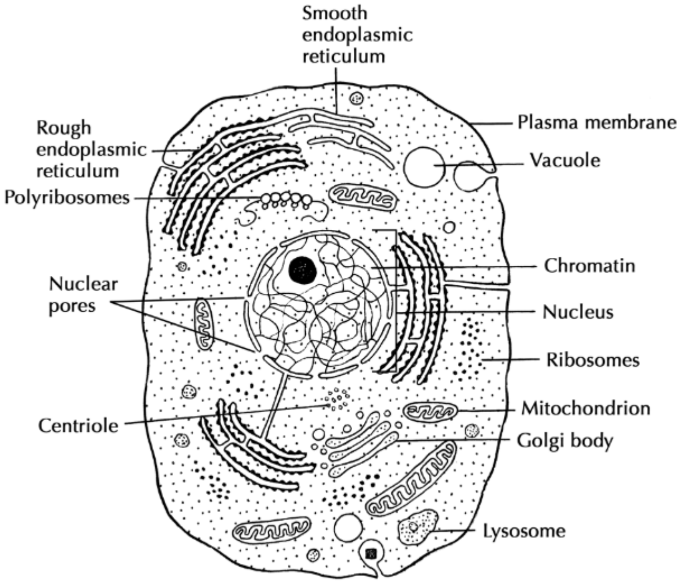


Fig. 2.2. The ultra structure of an animal cell

All eukaryotic cells are not identical. Plants and animal cells are different as the plants posses cells walls, plastids and a large central vacuole which are absent in animal cells. Animal cells have centrioles which are absent in almost all plant cells. Now let us look at cell organelles to understand their structure and vital functions.

2.3. Cell organelles

A) Nucleus: The nucleus as a cell organelle was first described by Robert Brown as early as 1831. It is known as the cell's "command center," the nucleus is a large organelle that stores the cell's DNA (deoxyribonucleic acid). The nucleus controls all of the cell's activities, such as growth and metabolism, using the DNA's genetic information. Within the nucleus is a smaller structure called the nucleolus, which houses the RNA (ribonucleic acid). RNA helps convey the DNA's orders to the rest of the cell and serves as a template for protein synthesis.

The **nucleus** contains most of the genetic material (DNA) of the cell. Additional DNA is in the mitochondria and (if present) chloroplasts. The nuclear DNA is complexed with proteins to form chromatin, which is organized as a number of linear chromosomes. Genetic control of the cell is carried out by the production of RNA in the nucleus and the subsequent transfer of this RNA to a ribosome in the cytoplasm, where protein synthesis is directed. The resulting proteins carry out cell functions. Also located in the nucleus is the nucleolus or nucleoli, organelles in which ribosomes are assembled. The nucleus is bounded by a nuclear envelope, a double membrane perforated with pores and connected to the rough endoplasmic reticulum membrane system.

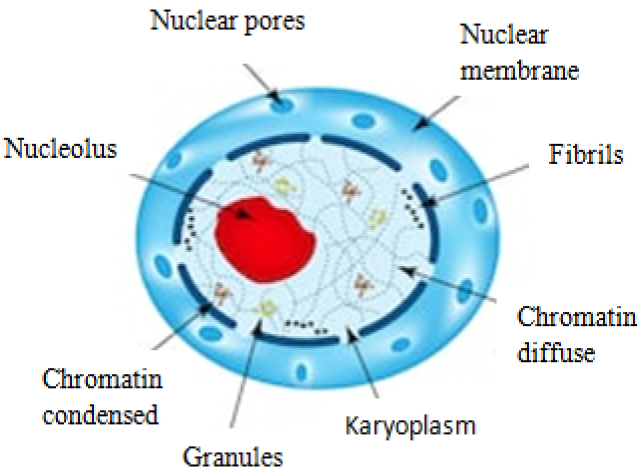


Fig. 2.3. Structure of Nucleus

B) Ribosomes: These are granular structures first observed under the electron microscope as dense particles by George Palade (1953). The endoplasmic reticulum (ER) is a membranous organelle that shares part of its membrane with that of the nucleus. Some portions of the ER, known as the rough ER, are studded with ribosomes and are involved with protein manufacture. The rest of the organelle is referred to as the smooth ER and serves to produce vital lipids (fats).

A **ribosome** is the site of protein synthesis in the cell. Each ribosome consists of a large subunit and a small subunit, each of which contains rRNA (ribosomal RNA) and ribosomal proteins. The eukaryotic ribosomes are 80S while the prokaryotic ribosomes are 70S. Both types of ribosomes are composed of larger and smaller subunits. 70S ribosome contains 50S and 30S subunits while the other type contains 60S and 40S subunits. The two subunits in both types of ribosomes associate with each other in the presence of Magnesium ions. In protein synthesis, the mRNA (messenger RNA) moves through the ribosome while amino acids attached to tRNAs (transfer RNAs) are brought to the ribosome. The amino acids are joined to produce the protein. Ribosomes exist free in the cytoplasm and bound to the endoplasmic reticulum (ER).

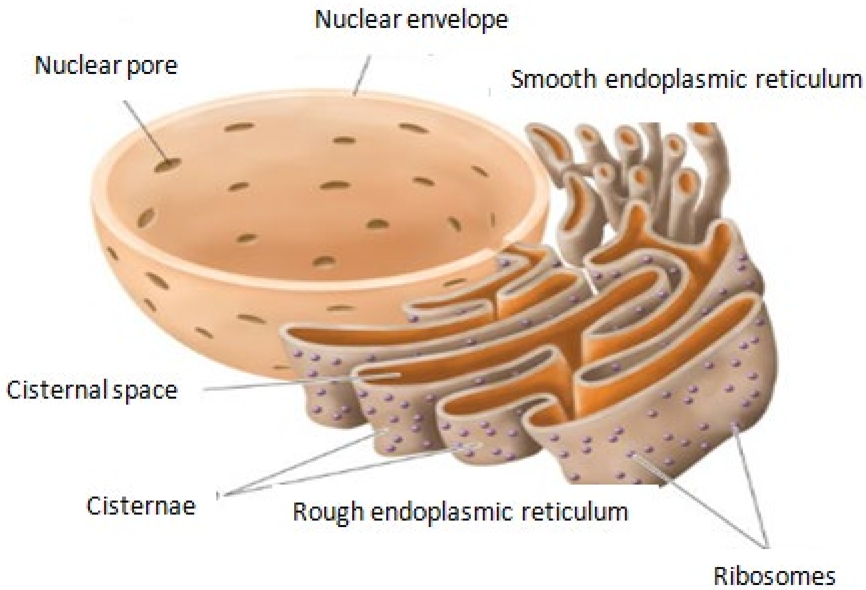


Fig. 2.4. Endoplasmic reticulum

C) Plasma membrane: It is also called the cell membrane, is a phospholipid bilayer with embedded proteins that encloses every living cell. This membrane blocks uncontrolled movements of water-soluble materials into or out of the cell. The various proteins embedded in the phospholipid bilayer penetrate into and through the bilayer three-dimensionally. It is the proteins of the membrane that are responsible for the specific functions of the plasma membrane. These functions include controlling the flow of nutrients and ions into and out of the cells, mediating the response of a cell to external stimuli and interacting with bordering cells. All membranous eukaryotic cell organelles have the common feature of a phospholipid bilayer, although the proteins differ in each case.

D) Golgi apparatus: Camillo Golgi (1898) first observed densely stained reticular structures near the nucleus and these were later named Golgi bodies after him. They consist of many flat, disc-shaped sacs of cisternae of 0.5 to 1.0 milli microns diameter. These are stacked parallel to each other. Varied number of cisternae are present in a Golgi complex. The Golgi cisternae are concentrically arranged near the nucleus with distinct convex *cis* or the forming face and concave *trans* or the maturing face. The *cis* and the *trans* faces of the organelle are entirely different, but interconnected.

If the proteins from the rough ER require further modification, they are transported to the Golgi apparatus or Golgi complex. Like the ER, the Golgi apparatus is composed of folded membranes. It searches the protein's amino acid sequences for specialized "codes" and modifies them accordingly. These processed proteins are then stored in the Golgi or packed in vesicles to be shipped elsewhere in the cell.

E) Chloroplasts: In plants and some algae, organelles known as chloroplasts serve as the site of photosynthesis. Chloroplasts contain a pigment known as chlorophyll, which captures the sun's energy to transform water and carbon dioxide into glucose for food. Chloroplasts allow autotrophic organisms to meet their energy needs without consuming other organisms.

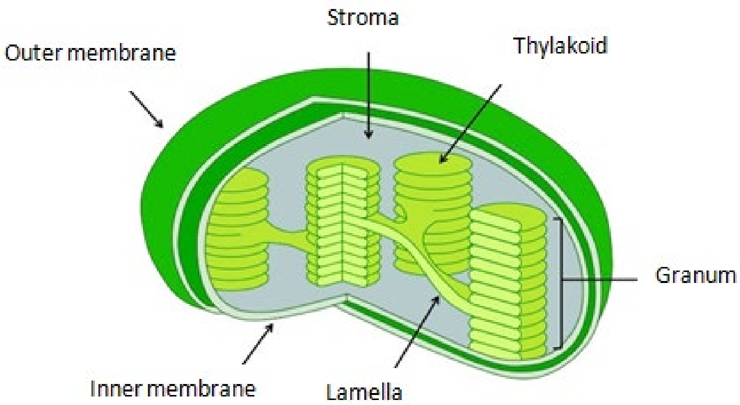


Fig.2. 5. Structural view of Chloroplast

Chloroplasts are large organelles bounded by a double membrane and containing DNA. Unlike the mitochondrial double membrane, the inner membrane is not folded. Distinctly separate from the double membrane is an internal membrane system consisting of flattened sacs and called thylakoids. The space between the thylakoid and the outer membranes is called the stroma. The stroma contains the chloroplast DNA as well as components of the protein synthesizing machinery specific for the chloroplast, namely the ribosomes, tRNAs, and specific proteins and enzymes. Most of the components of photosynthesis are located in the thylakoids. The thylakoid membranes are organized into stacks called grana. In addition, there are flat membranous tubules called the stroma lamellae connecting the thylakoids of the different grana. The membrane of the thylakoids encloses a space called a lumen. The ribosomes of the chloroplasts are smaller (Prokaryotic, 70S) than the cytoplasmic ribosomes (Eukaryotic, 80S).

F) Mitochondria: The "powerhouses" of the cell, mitochondria are oval-shaped organelles found in most eukaryotic cells. The number of mitochondria per cell is variable depending on the physiological activity of the cells. As the site of cellular respiration, mitochondria serve to transform molecules such as glucose into an energy molecule known as ATP (Adenosine triphosphate). ATP fuels cellular processes by breaking its high-energy chemical bonds. Mitochondria are most plentiful in cells that require significant amounts of energy to function, such as liver and muscle cells.

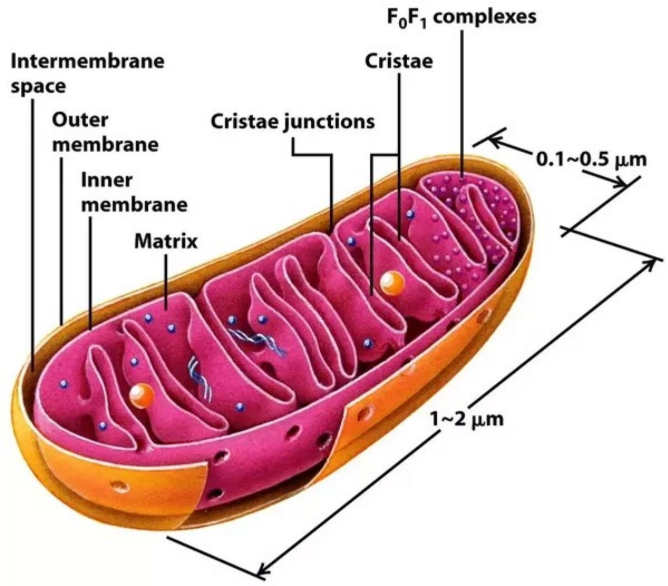


Fig. 2.6. Structure of Mitochondrion

Mitochondria are the sites of cellular respiration, a process that generates ATP from substrates in reactions using oxygen. All eukaryotic cells contain mitochondria, often many hundreds per cell. Each mitochondrion having a diameter of 0.2 – 1.0 µm and length 1.0 – 4.1µm. Mitochondria contain the enzymes and other components needed for the enzyme complexes that catalyze respiration. The primary function of mitochondria is to synthesize ATP from ADP and Pi (Inorganic phosphate).

Each mitochondrion is a double membrane bound structure with the outer membrane and the inner membrane dividing its lumen distinctly into two aqueous compartments *i.e.* the outer compartment and the inner compartment. The inner compartment is called the matrix. The outer membrane forms the continuous limiting boundary of the organelle. The inner membrane forms a number of infoldings called the cristae towards the matrix. The cristae increase the surface area. The two membranes have their own specific enzymes associated with the mitochondrial function. Mitochondria are the sites of aerobic respiration. The matrix also possesses single circular DNA molecule, a few RNA molecules, ribosomes (70S) and the components required for the synthesis of proteins.

G) Vacuoles: The vacuole is the membrane bound space found in the cytoplasm and most common to plant cells. It contains sap mainly composed of water, metabolic bye-products, excretions and other waste materials. The vacuole is bound by a single membrane called tonoplast. In plant cells, the vacuoles can occupy up to 90 per cent of the volume of the cell and play important role in osmoregulation. In plants, the tonoplast facilitates the transport of number of ions and other materials against concentration gradients into the vacuole. Hence their concentration is significantly higher in the vacuole than in the cytoplasm.

H) Lysosomes: These are membrane bound vesicular structures formed by the process of packaging in the golgi apparatus. The isolated lysosomal vesicles have been found to be very rich in hydrolytic enzymes capable of digesting carbohydrates, proteins, lipids and nucleic acids. The function of lysosomes is to remove waste as well as destroying a cell after it has died, called autolysis. A lysosome is an organelle containing digestive enzymes which it uses to function as the digestion and waste removal for cells, food particles, bacteria, etc.

Table 2.1. Difference between Prokaryotic and Eukaryotic cell

Cell organelles	**Prokaryotes**	**Eukaryotes**
Cell and cell size	Always unicellular and the size lies in between 0.2- 2.0 micrometers in diameter	Mostly multi-cellular and the size lies in between 10 – 100 mm in diameter
Cell wall	Usually present; chemically complex in nature	When present, chemically simple in nature
Nucleus	Is absent	Is present
Ribosomes	These cells consist of ribosomes which are smaller in size and circular in shape when compared to the cells of eukaryotes.	The ribosomes of eukaryotes are larger in size and are linear in shape.
DNA arrangement	Circular in shape	Linear in shape
Mitochondria	Is absent	Is present
Cytoplasm	The cytoplasm in prokaryotes does not contain the endoplasmic reticulum	In this, the cytoplasm has the endoplasmic reticulum
Plasmids	Present in prokaryotes	Very rarely found in eukaryotes
Ribosome	Small ribosomes.	Large ribosomes.
Lysosome	In this, the lysosome, mesosome, and centrosome is absent	Mesosome, Lysosomes, and centrosomes are usually present in Eukaryotes
Cell division	Through binary fission	Through mitosis
Flagella	The flagella is smaller in size in prokaryotes	The flagella is larger in size in case of eukaryotes
Reproduction	Asexual	Both asexual or sexual

Table 2.2. Cell organelles and their Functions

Cell organelles	Functions
Cell wall	Provide support, shape and protects the internal organelles of cells.
Cell membrane (or) Plasma membrane	Controls the secretion of proteins and elimination of waste products.
Cytoplasm	They are the site of cellular activities.
Nucleus	The storehouse of the cell's genetic materials. It plays a primary role in reproduction and guides the activity of a cell.
Nucleolus	It is the site of manufacturing cell's ribosomes, involved in controlling cellular activities and cellular reproduction.
Nuclear membrane	Protects nucleus by forming a boundary in between the nucleus and other cell organelles.
Chromosomes	They play an important role in determining a sex of an individual.
Endoplasmic reticulum	Involved in the transportation of substances throughout the cell. It plays a primary role in the metabolism of carbohydrates, synthesis of lipids, steroids and proteins.
Golgi Bodies	It is called as the cell's post office as it is involved in the transportation of materials within the cell.
Ribosome	They are the protein synthesizers of the cell.
Mitochondria	It is called as the cell's powerhouse as it is involved in producing and transforming the energy (ATP).
Lysosomes	It protects the cell by engulfing the foreign bodies entering the cell and helps in cell renewal. Therefore, it is the cell's suicidal bags.
Chloroplast	They are mainly involved in photosynthesis. As it contains the green colored pigment called chlorophyll.
Vacuoles	Stores food, water, and other waste materials.

2.4. CELL DIVISION

There are 3 types of cell divisions. They are,

A. **Amitosis –** direct cell division
B. **Mitosis –** indirect cell division
C. **Meiosis –** reduction cell division

2.4.1. AMITOSIS: This type of cell division is very simple and takes place in unicellular organisms. It is a type of cell division which involves no spindle formation. In this, cell division starts with elongation of the nucleus and becomes dumbbell shaped. In this case the nucleus (nucleoid) divide directly into two daughter nuclei therefore amitosis is described as direct division.

2.4.2. MITOSIS

Mitosis or indirect cell division is a simple type of cell division in which new cells are formed in the growing regions (stem tip, root tip, cambium). Mitosis occurs in somatic (vegetative) cells. Hence it is called somatic division. Mitosis results in the formation of two identical daughter cells. Therefore it may be considered as equatorial division.

The dividing cell passes through two main phases 1.Interphase, 2. Mitotic phase (M Phase). The M Phase often called phase of apparent division, represents the phase when the actual cell division or mitosis occurs and the interphase represents the phase between two successive M phases.

I. **INTERPHASE:** The resting stage between the two mitotic divisions is called Interphase. This is the longest phase of the cycle in which the nuclear and cytoplasm contents increase in volume. During Interphase, the chromosomes remain usually uncoiled. Interphase has three sub-phases.

   A. **G1 phase (Gap 1):** It is pre synthesis period of DNA and different types of proteins and enzymes. During this phase, the cell is metabolically active and continuously grown but does not replicate its DNA.

B. S phase (Synthesis): It is the period during which DNA synthesis or replication takes place. During this time the amount of DNA per cell doubles. However, there is no increase in the chromosome number.

C. G2 phase (Gap 2): During this phase, proteins are synthesized in preparation for mitosis while cell growth continues.

In animals, mitotic cell division is only seen in the diploid somatic cells whereas in the plants can show mitotic divisions in both haploid and diploid cells.

2. Mitotic Phase: The main and active phase of a cell-cycle is the mitotic division, which can be distinguished into karyokinesis.

A. **Karyokinesis (Nuclear division):** The division of nucleus during cell division is called Karyokinesis. It is lengthy and continuous process, it results in the formation of two identical daughter nuclei. It is divided into four stages or phases. They are Prophase, Metaphase, Anaphase and Telophase.

Prophase: During Prophase the chromatin material gets itself organized into clear, long thread-like structures called chromosomes. From the inception of prophase each chromosome appears to be a double structure due to the presence of two chromatids formed as a result of duplication of DNA. The two chromatids of the same chromosome are called sister chromatids. They contain identical genetic information. The sister choromatids are help together at a point called centromere or kinetochore. As Prophase progresses, the long, slender, chromosomes become shorter, thicker and more distinct. The nuclear membrane and nucleous gradually disappear. The completion of prophase can thus be marked by the following characteristic events.

- Chromosomal material condenses and organizes to form compact mitotic chromosomes. The Chromosomes are seen to be composed of two chromatids attached together at the centromere.
- Initiation of the assembly of mitotic spindle, the microtubules, the proteinaceous components of the cell cytoplasm help in the process.

Cells at the end of prophase, when seen under microscope, do not show golgi complexes, endoplasmic reticulum, nucleolus and the nuclear envelope.

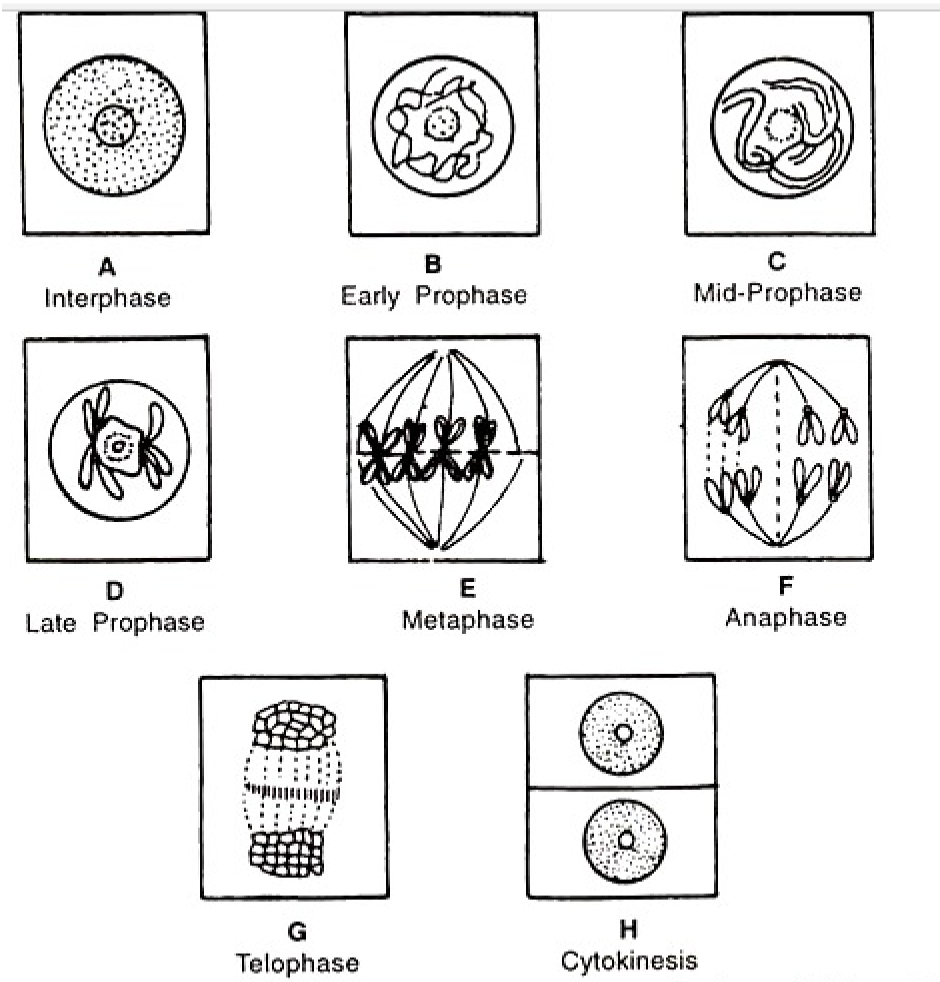


Fig. 2.7. Various stages during mitotic cell division

Metaphase:

The transition between prophase and metaphase is sometimes called as pro-metaphase. It is a very short period in which the nuclear envelop disintegrates and the chromosomes are in apparent disorder. After that, the spindle fibers invade the central area and extend between the poles. Spindle fibres are formed by the union of micro tubules. The chromosomes are arranged at the equatorial plane with the help of spindle fibres and appear as a plate called equatorial plate. The spindle fibres extend from pole to pole called continuous spindle fibres which extend from pole to equatorial plane and get attached to the chromosomes with protein disc of centromere region called chromosomal spindle fibres. The key features of metaphase are:

- Spindle fibres attach to kinetochores of chromosomes.
- Chromosomes are moved to spindle equator and get aligned along metaphase plate through spindle fibres to both poles.

Anaphase: In this phase, sister chromatids also separate at the centromere region (centromere divides). Each of the sister chromatids with its own centromere acts as daughter chromosome. Daughter chromosome separate and migrates towards opposite poles. The daughter chromosomes assume the shape of V, U or J depending upon the position of centromeres. The centromeres are pulled by the chromosomal fibers of the spindle (towards the poles) once, they considered as daughter chromosomes. The key events of the Anaphase is as follows.

- Centromeres split and chromatids separate.
- Chromatids move to opposite poles

Telophase: The end of the polar migration of the daughter chromosomes marks the beginning of telophase. The chromosomes start to uncoil and form masses, of chromatin which will be surrounded by a nuclear envelope. Hence two identical new daughter nuclei appear in a single cell which marks the end of karyokinesis. During the final stages the nucleoli reappear at the sites of the nucleolar organizers. The key events of this phase are:

- Chromosomes cluster at opposite spindle poles and their identity is lost as discrete elements.
- Nuclear envelope assembles around the chromosome clusters.
- Nucleolus, golgi complex and Endoplasmic Reticulum reforms.

B. Cytokinesis (Division of cytoplasm): It is the process of segmentation and separation of the cytoplasm. During cytokinesis, the cytoplasmic components like mitochondria, plastids etc. are distributed.

In plant cells, the equatorial region is transformed into phrogmoplast. The phragmoplast comprise microtubules and Golgi vesicles. In course of time the phragmoplast will be transformed into cell plate or fluid plate having calcium, magnesium pectates. This acts as the middle lamellum. On either side of middle lamellum new substance of cellulose is laid down to from a conspicuous cell wall between the two daughter cells. The cell wall formation (between the daughter nuclei) leads to the formation of two daughter cells.

Significance of Mitosis: Mitosis or the equational division is usually restricted to the diploid cells only and however in some lower plants haploid cells also divide by mitosis. Usually it is very significant due to the following reasons.

1. Mitosis maintains a definite size of the cell.
2. Vegetative and asexual propagation takes place through mitosis.
3. The chromosomal number is maintained constantly both in parent cell and in daughter cells (due to the duplication of DNA).
4. Development of an organism takes place through mitosis.
5. Wound healing and regeneration of tissues are possible with mitosis.

2.4.3. MEIOSIS

The process of cell division occurring in the reproductive cells in which the diploid number of chromosomes is reduced to half to that of the parent cell is known as meiosis or reduction division. It is a complicated process restricted only to the reproductive cells of both plants and animals. The term meiosis was coined by Farmer and Moore in 1905. The cells in which meiosis occurs are called meiocytes. In plants, usually the spore- mother cells or sporocytes are the meiocytes.

Meiosis involves two nuclear divisions (Fig. 2.8.)

a. First Meiotic division or reduction division or heterotypic division in which the chromosome number is reduced to half.

b. Second Meiotic division or equational division or homeotypic division-which is a mitotic division.

Like mitosis, meiosis also has four phases in the nuclear division they are Prophase, Metaphase, Anaphase and Telophase of I Meiotic and II meiotic division.

A. First Meiotic Division

Prophase 1: It a lengthy phase when compared to prophase of mitotic division, involving a series of complicated changes. The changes occurring in the nucleus are carried on in five sub-phases like 1. Leptotene 2. Zygotene 3. Pachytene 4. Diplotene 5. Diakinesis.

1. **Leptotene or Leptonema:** The chromatin network of meiocytic nucleus resolves and the Chromonemata (chromosomes) become more distinct and appear as long and slender threads. Each chromosome consists of two chromatids.

2. **Zygotene or Zygonema:** During zygotene homologous chromosomes starts pairing. Pairing of homologous chromosomes called synapsis. The pairing of chromosomes may begin at any point along the entire length and extends in a zipper like fashion.

3. **Pachytene or pachynema:** The synaptic chromosomes forming the pair become more thick and short. Each chromosome is composed of two spiral filaments called the chromatids, the bivalent thus contains four chromatids and is also called a tetrad. Exchange of segments between non-sister chromatids is called crossing over which results in cross like structures called chiasmata. Chromosomes become thickened and shortened.

4. **Diplotene or Diplonema:** During diplotene the paired chromosomes begin to separate but remain united at chiasmata.

5. **Diakinesis:** This is marked by terminalization of chiasmata. During this phase, the chromosomes are fully condensed and the meiotic spindle is assembled to prepare the homologous chromosomes for separation. By the end of diakinesis, the nucleolus disappears and the nuclear envelope also breaks down. Diakinesis represents transition to metaphase.

Metaphase 1: The bivalent chromosomes align on the equatorial plate. The microtubules from the opposite poles of the spindle attach to the paid of homologus chromosomes.

Anaphase I: The homologous chromosomes separate while sister chromatids remain associated at their centromeres.

Telophase 1: When the chromosomes reach the poles, telophase I is considered to begin. Each pole receives half the number of somatic chromosomes. This stage is quite variable in different species. During this stage, the chromosomes may be partly uncoiled and the nuclear membrane may be formed. Later, cytokinesis may produce two cells which remain attached together; they are called dyad

Cytokinesis may occur either at the end of meiosis I or it may be postponed till the end of meiosis II. The stage between the two meiotic divisions is called interkinesis and is generally short lived. Interkinesis is followed by prophase II, a much simpler prophase than prophase I.

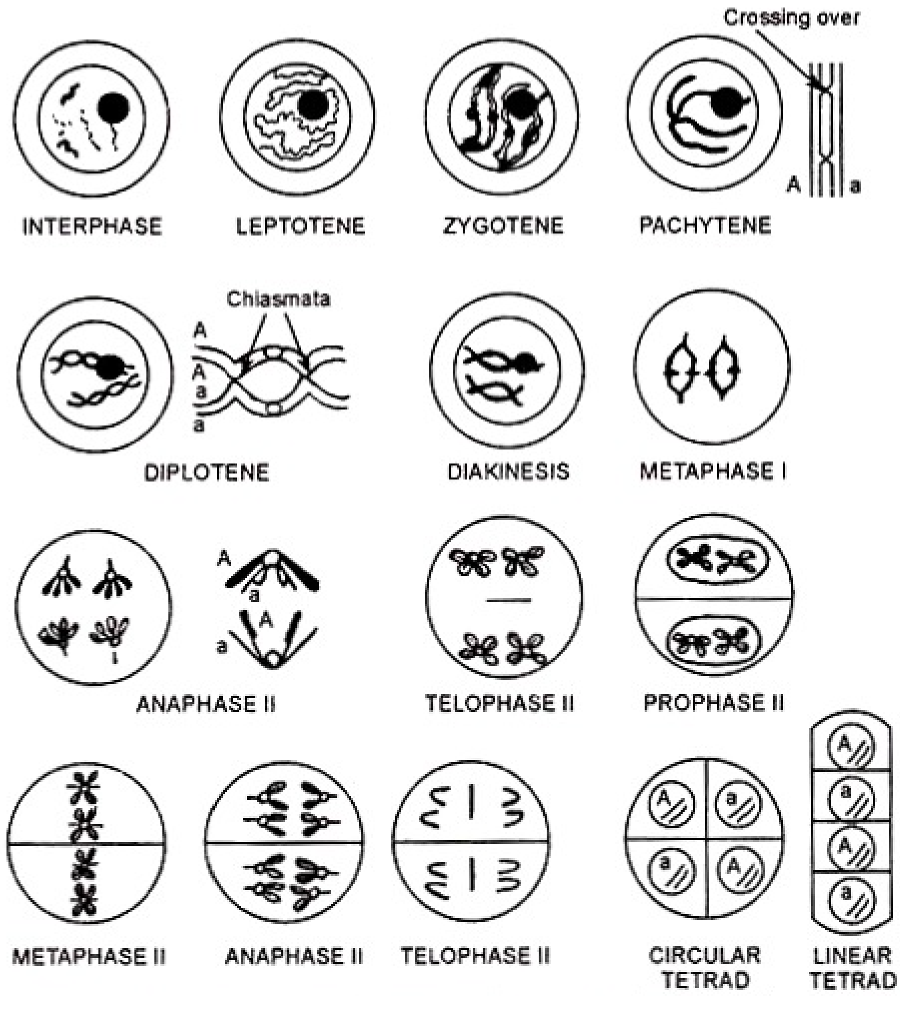


Fig. 2.8. Various stages during meiotic cell division

Meiosis II:

During interkinesis, the two nuclei are fairly large and the chromatids occur as slender threads. The first division is followed by equational division or second Meiotic division. The meiosis II, also consists of four phases as follows – prophase I1, Metaphase II , Anaphase II and Telophase II.

Prophase II: Nucleolous and nuclear envelop disappear. Chromosomes (dyad) becomes short and thick.

Metaphase II: Two spindles are formed at right angles to the spindle of metaphase I. The chromosomes are arranged on the equatorial plane by means of spindle fibres.

Anaphase II: Two centromeres divide and the daughter chromosomes are pulled to opposite poles and chromatids assume different shapes like U, V, J, or L.

Telophase II : The chromatids reach the poles and are reorganized into daughter nuclei. The two groups chromosomes once again get enclosed by a nuclear envelope, cytokinesis follows resulting in the formation of tetrad of cells i.e. four haploid daughter cells. Thus at the end of Meiosis II, four daughter nuclei are formed, each with a haploid number of chromosomes.

Significance of Meiosis:

i. Meiosis is a type of division in which diploid chromosome number is reduced to haploid number in gametes or spores. Thus the chromosomal number is maintained constantly even after sexual reproduction.
ii. During meiosis crossing over occurs, the genetic phenomenon is mainly responsible for giving rise to 'variations' which is the first step of evolution. Variations are very important for the process of evolution.
iii. Meiosis is a cytological proof of Mendel laws of segregation and independent assortment.
iv. The meiotic pairing of homologous chromosomes is a clear proof of mixing up of both maternal and paternal characters.

2.5. GENETICS

In 1839, German microscopists Matthias Schleiden and Theodor Schwann put forward the cell theory, which proposed that all plants and animals are constructed from small fundamental units called cells and all cells arise from pre-existing cells. Cells arise from other cells by the process of cell division. Hence, the cells are the body's building blocks. Cells contain an inner body known as Nucleus, which contains a fixed number of linear bodies called 'Chromosomes'. Many different types of cells have different functions. They make up all of your body's organs and tissues. Nearly every cell in a person's body has the same deoxyribonucleic acid, or DNA. DNA is the hereditary material in humans and almost all other organisms. Most DNA is located in the cell nucleus (where it is called nuclear DNA), but a small amount of DNA can also be found in the mitochondria (where it is called mitochondrial DNA).

DNA is a major genetic element present in almost all living organisms. It is present in the nuclei of eukaryotic cells and in the protoplasm of prokaryotic cells. In prokaryotic cells, the DNA occurs freely in the form of nucleoid. But in eukaryotic cells, DNA is associated with chromosomal proteins in the form of chromosomes. DNA contains the code for building and maintaining an organism. The code is spelled out in the order, or sequence, of four chemical bases such as adenine (A), cytosine (C), guanine (G) and thymine (T), in the same way that letters of the alphabet come together to form words, sentences, and paragraphs. Human DNA consists of about three billion bases, and more than 99 percent of those bases are the same in all people.

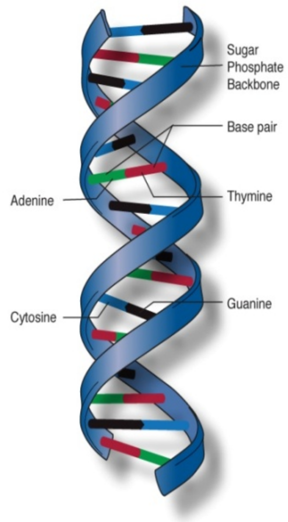


Fig.2.9. Structure of DNA molecule

DNA bases pair with each other—A with T, C with G—to form units called base pairs. Each base is attached to a sugar molecule and a phosphate molecule. Together, base, sugar, and phosphate are called a nucleotide. Nucleotides are arranged in two long strands that form a spiral called a double helix. The structure of the double helix is like a ladder, with base pairs running through the middle like rungs and sugar and phosphate molecules along the outside.

Genes are small sections of the long chain of DNA. They are the basic physical and functional units of heredity. In humans, genes vary in size from a few hundred DNA bases to more than two million bases. The Human Genome Project has estimated that humans have between 20,000 and 25,000 genes. Every person has two copies of each gene, one inherited from each parent. Most genes are the same in all people, but a small number of genes (less than one percent of the total) are slightly different between people. Alleles are forms of the same gene with small differences in their sequence of DNA bases. These small differences contribute to each person’s unique features.

Genes act as instructions to make molecules called proteins. To function correctly, each cell depends on thousands of proteins to do their jobs in the right places at the right times. Sometimes changes in a gene, called mutations, prevent one or more of these proteins from working properly. This may cause cells or organs to change or lose their function, which can lead to a disease. Mutations, rather than genes themselves cause disease. For example, when people say that someone has “the cystic fibrosis gene,” they are usually referring to a mutated version of the CFTR gene, which causes the disease. All people, including those without cystic fibrosis, have a version of the CFTR gene.

Sections of DNA form genes and many genes together form chromosomes. People inherit two sets of chromosomes (one from each parent), which is why every person has two copies of each gene. Humans have 46 chromosomes (23 pairs). Genes are inherited as units, with two parents dividing out copies of their genes to their offspring. This process can be compared with mixing two hands of cards, shuffling them, and then dealing them out again. Humans have two copies of each of their genes, and make copies that are found in eggs or sperm—but they only include *one* copy of each type of gene. An egg and sperm join to form a complete set of genes. The eventually resulting offspring has the same number of genes as their parents, but for any gene one of their two copies comes from their father and one from their mother.

Genetics is a field of biology that studies how the traits are passed from parents to their offspring. The passing of traits from parents to offspring is known as heredity, therefore, genetics is the study of heredity. This introduction to genetics deals with the basic components of genetics such as DNA, genes, chromosomes and genetic inheritance. Genetics is built around molecules called DNA and these molecules hold all the genetic information for an organism. It provides cells with the information they need to perform tasks that allow an organism to grow, survive and reproduce. A gene is one particular section of a DNA molecule that tells a cell to perform one specific task.

Heredity is what makes children look like their parents. During reproduction, DNA is replicated and passed from a parent to their offspring. This inheritance of genetic material by offspring influences the appearance and behavior of the offspring. The environment that an organism lives in can also influence how genes are expressed.

One of the fundamental in biology was how to predict what characters will appear in an organism and how they are inherited to their next generation. It was Gregor Mendel who proposed the basic rules of inheritance in 1865.

2.5.1. Mendel Principles of Genetics

The contribution of Mendel to genetics is called **Mendalism and Gregor J. Mendel** (1822-84) is considered as the 'Father of Genetics' who made revolutionary contributions with his experiments which demonstrated the principles and concepts of hereditary transmission of characters. He was a monk and later an abbot of monastery in Briinn, Austria, he was the first person to conduct decisive experiments in heredity and to establish facts of heredity experimentally and it was he who formulated the underlying principles and basic laws of genetics. In 1900 Mendel's principles were rediscovered by three different investigators, they are DE VERIES (HOLLAND), CORRENS (GERMANY), Van TSCHERMAC (AUSTRIA).

2.5.2. Reasons for Mendal's success: He did hybridization experiments on different types of Pea plants. He selected Pea (*Pisum sativum)* as experimental material because it is self pollinated, shows number of clear cut contrasting characters (allelomorphs or allels), perfectly fertile, successful artificial pollination, cross pollination is not difficult. Genes for the seven pairs of characters are located on separate homologous pairs of chromosomes, cultivation of plant is easy, shortest growth period, availability of many pure breeding varieties, focused on only one character at a time. Though the pea plant consist several contrasting characters, Mendel selected only seven characters such as tall or short plants, red or white flowers, yellow or green seeds, round or wrinkled seeds, smooth or wrinkled pods and so on. Mendel in his first experiment crossed two plants differing in one character (hight) only**.** Such crosses, where parents differ in one pair of alternative characters are known as mono hybrid cross, resulting hybrids are known as mono hybrids**.** Mendel also crossed two plants differing in two characters, such as flower position and height of the stem. Such crosses called as di-hybrid cross and resulting hybrids are called as di-hybrids. The two plants involved in the above cross are called parent plants P. The first hybrid generation is called first filial generation (F1), the second hybrids arising by self or cross fertilization is called second filial generation (F2)**.** First Mendel considered mono hybrid cross, only one pair of contrasting characters, such as tall and dwarf stem, his experiment is represented graphically as below.

TALL x DWARF………….. (P)

TALL TALL x TALL……….. F_1

TALL TALL TALL DWARF ------ F2 ---- 3:1 ratio.

On crossing the TALL and DWARF, the individuals of F_1 have both characters of TALL and DWARF, Mendel called these '**hybrids',** but from the pair of contrasting characters only the TALL appears, and is called **dominant,** though the DWARF character is present in them is hidden or over shadowed and is called **recessive**, but it will be transmitted to later generations without being changed. Mendel found that out of total of 1,064 plants of F_2 there were 787 TALL and 227 DWARF that is roughly in the proportion of **3:1.** From these experiments Mendel proposed three principles called

2.6. Mendel laws.

1. **Law of Dominance:** Mendal's law of dominance states that "One factor in a pair may mask or prevent the expression of the other". He called the factors that appear in the F1 generation of his mono hybrid cross as dominant and those did not appear F1 generation as

recessive. It means that an organism with alternate forms of a gene will express the form that is dominant. This law is formulated based on the mono hybrid experiment**.**

2. **Law of segregation:** This states that, "during gamete formation the genes of particular character separate and randomly enter different gametes". This law is also formulated based on monohybrid experiment. Each inherited trait is defined by a gene pair. Parental genes are randomly separated to the sex cells **so** that sex cells contain only one gene of the pair. Offspring therefore inherit one genetic allele from each parent when sex cells unite in fertilization.

   According to both laws each organism is formed of bundle of characters and each character is controlled by a pair of factors or genes.

3. Law of Independent assortment: According to this law, "The genes for each pair of characters separate independently from those of other characters during gamete formation". It means that Genes for different traits are sorted separately from one another so that the inheritance of one trait is not dependent on the inheritance of another. This law is based on dihybrid cross between a red-flowered and a white- flowered pea plant showing incomplete dominance.

Mendel proceeded to consider several pairs of contrasting characters in his peas, he noted the behavior of two or more sets contrasting characters combined in the some group of individuals and their descendants. The contrasting characters he considered in peas were round yellow seeds and wrinkled green seeds, close are two pairs of contrasting characters and he crossed such plants.

Dihybrid cross: The crossing of two plants with two different characters is called di-hybrid cross. In dihybrid experiment Mendel selected two characters, *i.e* cotyledon colour (yellow & green) and seed shape (round & wrinkle). The two plants as parents were crossed. The F1 generation plants produced only yellow-round seeds. Then F1 plants were self-fertilized, in F2 generation four kinds of plants *i.e*, plants producing yellow and round seeds, yellow and wrinkled seeds, green and round seeds and green and wrinkled seeds produced in phenotypic ratio *i.e*, 9:3:3:1 and genotypic ratio 1:2:4:1:2:1:2:1.

BACK CROSS: When F1 individuals are crossed with any of its parent or organisms that are phenotypically and genotypically similar to the parents is called back cross. If F1 hybrids is crossed with the parent having dominant traits no recessive individual is produced in the progeny.

TEST CROSS: When F1 individuals are crossed with recessive parent similar in phenotype and genotype to the recessive parent is called test cross. It is used to test whether an individual is homozygous (pure) or heterozygous (hybrid). A mono hybrid test cross gives phenotypic ratio of 1:1:1:1.

Mendel's contribution to the knowledge of heredity are, (a) In heredity the characters of an adult behave like units (factors) which are distributed to the offspring according to mathematical rules and can be expressed in dominant or recessive types in $F_{1.}$ (b) The characters are present as factors or units in gametes, and unit is neither lost nor mixed in inheritance, but it is inherited independently of other characters. (c) An offspring is pure breed if it receives identical units or factors from both its parents, but it is not pure breed, if it receives different factors from its two parents.

2. 7. ANATOMY: The structural similarities and variations in the external morphology of larger plants can be observed. Similarly if we study the internal structure, one also finds several similarities as well as differences. Study of different tissues in the plant body is called Histology and study of internal structure of plants is called Anatomy. The plants have cells as the basic unit, cells are organized into tissues and in turn the tissues are organized into organs. Different organs in a plant show differences in their internal structure. Within angiosperms, the monocots and dicots are also seen to be automatically different. Internal structures also show adaptations to diverse environments.

A tissue is a group of cells having a common origin and usually performing a common function. A plant is made up of different kinds of tissues. The tissues are classified as meristematic and permanent based on whether the cells being formed are capable of dividing or not. Growth in plants is largely restricted to specialized regions of active cell division called meristems. The cells of the permanent tissues do not generally divide further. Permanent tissues having all cells similar in structure and function are called simple tissues

2.7.1. The tissue systems: Tissues vary depending on their location in the plant body. Their structure and function would also be dependent on location. On the basis of their structure and location, there are three types of tissue systems. These are the a) epidermal tissue system b) the ground or fundamental tissue system and C) vascular or conducting tissue system. The epidermal tissue system forms the outer most covering of the whole plant body and comprises epidermal cells, stomata and the epidermal appendages. It is the outer most layer of the primary plant body. Epidermal cells are parenchymatous with a small amount of cytoplasm lining the cell wall and a large vacuole. The cells of epidermis bear a number of hairs which help in absorbing water from the soil.

All tissues except epidermis and vascular bundles constitute the ground tissue. It consists of simple tissues such as parenchyma, collenchyma and sclerenchyma. Parenchymatous cells are usually present in cortex, pericycle, pith and medullary rays. In leaves, the ground tissue consists of thin walled chloroplast containing cells and is called mesophyll. The vascular system consists of complex tissue, the phloem and the xylem. The xylem and phloem together constitute vascular bundles. In dicotyledonous stems, cambium is present between phloem and xylem. Such vascular bundles, because of the presence of cambium, possess the ability to form secondary xylem and phloem tissues and hence are called open vascular bundles. In the monocotyledons, the vascular bundles have no cambium present, hence they do not form secondary tissues and they are referred as closed. Some of the major difference between monocots and dicots is presented in table 2.3.

Table 2.3. The difference between monocot and dicot plants

Sl.No.	Monocots	Dicots
1	Embryo with single cotyledon	Embryo with two cotyledons
2	Major leaf veins parallel	Major leaf veins reticulated
3	Stem vascular bundles scattered	Stem vascular bundles in a ring
4	Roots are adventitious	Roots develop from radicle
5	Flower parts in multiples of three	Flower parts in multiples of four or five
6	Pollen with single furrow or pore	Pollen with three furrows or pores
7	Secondary growth absent	Secondary growth often present

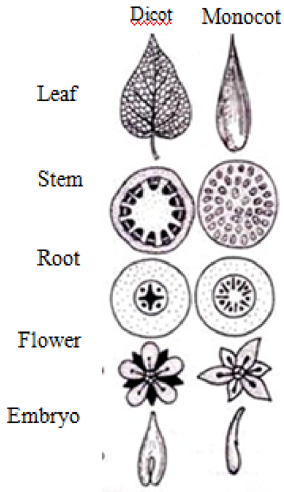


Fig. 2.10. Differences between dicots and monocots

2.8. Anatomy of mulberry root

Mulberry is a deep rooted perennial plant and its root system is very well developed though the growth and spread of the root depend upon the texture of the soil. The root tip shows the same structure as in other dicotyledonous plants. There is a clear differentiation of root cap which protects the growing meristmatic tissue from dessication and injury by the various soil organisms. The root hairs serve the function of absorption of water and salts from the soil.

2.8.1. Internal structure of a root: The morphology of a transverse section (TS) of the root before the formation secondary tissues shows that there is a single layered epidermis which consists of tubular shaped cells, closely arranged without intercellular space. Its outer walls are not cutinized and a few of the epidermal cells enlarge into root hairs. Below the epidermis there is a large cortex which consists wholly of parenchyma cells. There is a clear single layered endodermis enclosing the pericycle and vascular bundles. The vascular bundles are diarch or triarch, radial and without cambium. The pericycle is many layered which later forms the cork cambium.

Most of the water absorption is carried out by the younger part of the roots i.e. apical region, which shows three clear demarcations, the zone of meristamatic cells, the zone of elongation and the zone of absorption.

2.8.2. Structure of a secondary root: In the secondary root, some of the cells of parenchyma outside the protoxylem convert themselves into a small strip of cambium. These cambial strips divide and redivide to produce a sinuous cambium layer which later becomes circular. The cambium cuts off cells towards outside and inside. Simultaneously, some of the cells of pericycle also covert themselves into meristematic cells to form cork cambium. The cork cambium cuts off cells towards outside and inside, more cells towards inside than outside, thus more of secondary phloem is produced. The primary xylem strand remains undisturbed as main medullary ray. Thus in the secondary root, there is a thick bark including the primary cortex. The cork consists of rectangular cells whose contents are absorbed. Below the cork is the secondary phloem and secondary xylem are formed from the activity of the cambium.

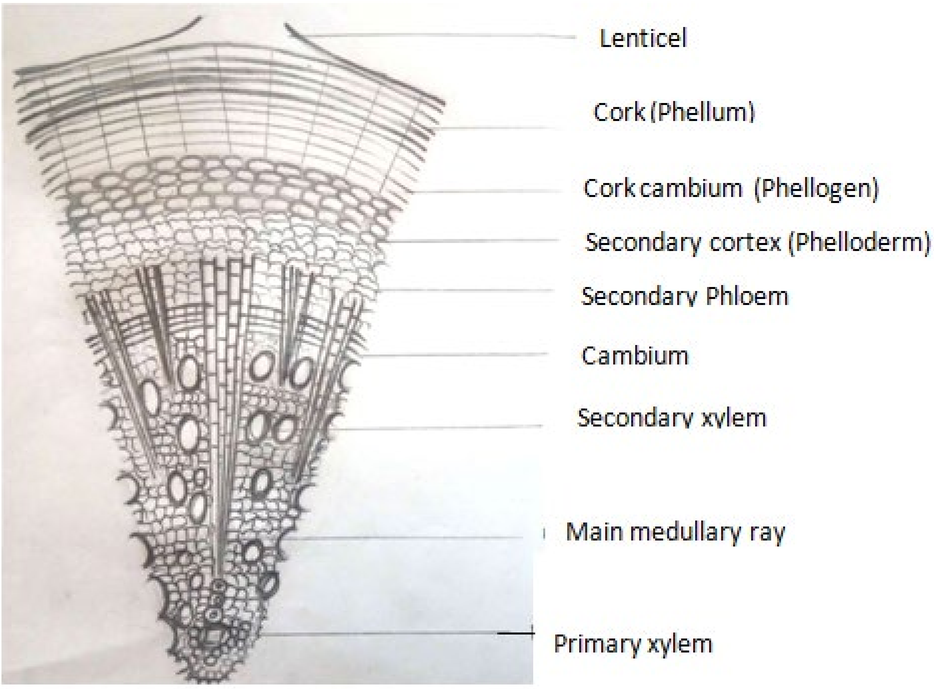


Fig. 2.11. Anatomy of secondary root

2.9. Anatomy of stem

The anatomy of the stem is similar to that of any dicotyledenous stem. The primary stem consists of a single layered epidermis with tubular shaped cells closely arranged without inter-cellular space. The outer cells of the epidermal cells are cutinised. Some epidermal cells are drawn into unicellular hairs which protect the plant from injurious insects and also minimize the rate of transpiration.

The epidermis is a multilayered cortex which consists of colio parenchyma cells. Some of the cells contain chloroplasts. There are many laticiferous cells in the cortex which are the storehouses of organic excretory products. There is a single layered endodermis with conspicuous barrel shaped cells. The pericycle is many layered. The vascular bundles are few, collateral, conjoined, open and endarch. There is a conspicuous medulla.

2.9.1. Secondary stem

The secondary stem of mulberry shows with the union of the cambial strips of the vascular bundles, a continuous ring of cambium is developed which cuts off secondary xylem towards inside and secondary phloem towards outside. Due to increase in the girth of the stem, the continuity of the epidermis is broken at various places. The function of protecting inner tissues is taken up by some of the cells or collenchymas, converting themselves into cork cambium which cuts off more cells towards outside and a few cells towards inside. Those cells that are formed towards outside form the cork or phellum and those that are formed towards inside form the secondary cortex or phelloderm. The phellogen with phellem and phelloderm is the periderm.

The cork cambium at some places, epidermis is broken and do not form the cork cells. The structure is called the lenticels which facilitates exchange processes. The secondary cortex consists of parenchyma cells transversed by many laticiferous cells. A group of sclerenchyma cells are also found in the cortex. The secondary phloem consists of well developed sieve tubes to conduct the food material. The cambium in between the phloem and the xylem cuts cells regularly, adding more of secondary tissues year by year. Due to increase in the girth of the stem, the primary xylem is pushed to the centre which is ultimately crushed to form the hard wood. The amount of wood produced in one year is called annual ring.

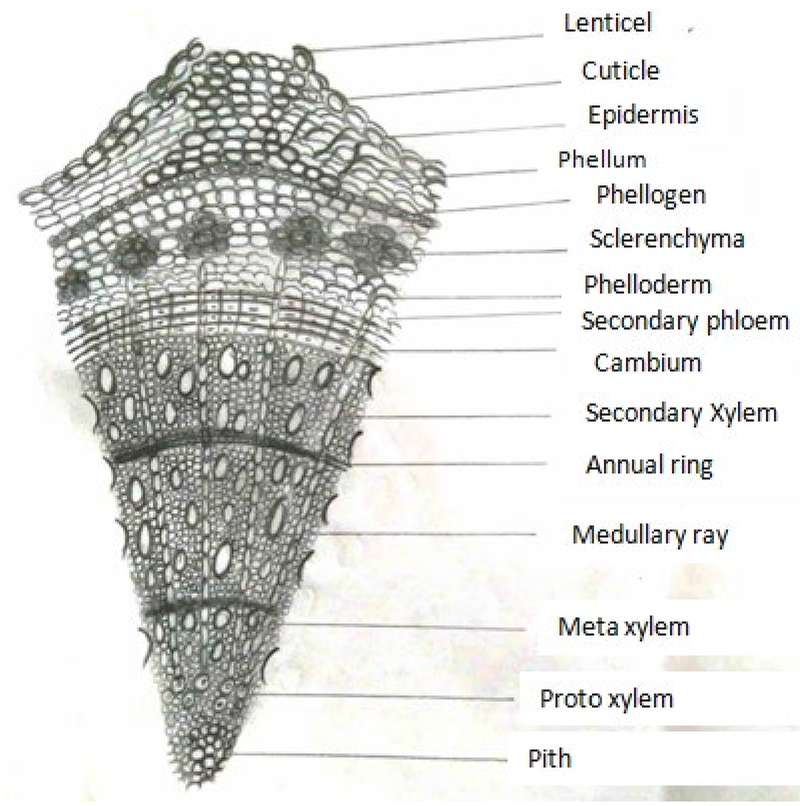


Fig.2.12. Anatomy of secondary stem

2.10. Anatomy of mulberry leaf

2.10.1. Anatomy of the petiole

The internal structure of the petiole of mulberry is like the primary tissues of the stem. The epidermis is single layered. Some of the cells are drawn into epidermal hairs in certain species. Below the epidermis, there is a supporting tissue of four to five layers of collenchymas cells. The ground parenchyma is like the cortex of the stem. The vascular bundles are collateral and scattered in the ground parenchyma in a circular manner in early stages. The phloem is oriented towards the periphery of the petiole.

2.10.2. Anatomy of leaf blade

The leaves are dorsiventral with reticulate venation. The upper epidermis consists of a single layer of tubular shaped cells closely arranged without intercellular space. However, the continuity is broken at certain places due to enlargement of the cells in the form of idioblasts. The idioblasts contain deposits of calcium carbonate. Based on the shape of the idioblast, morus species is classified as 'Dolichocystolithiae (narrow beak)' and 'Brachycystolithiae (broken beak)’. The outer walls are cutinized and a layer of cuticle is found. The thickness of the cuticle varies with mulberry variety. Those with thinner cuticle, thinner leaf blade and fewer number cystoliths are more palatable to silkworms.

The lower epidermis is much like the upper epidermis but with a thinner cuticle and stomata. Idioblasts are absent. Number of stomata per unit area of leaf, size of the stoma and size of the guard cells varies from diploid to polyploids. The palisade parenchyma is usually a single layer of closely packed, elongate-prismatic shaped cells with their long axes at right angles to the upper epidermis with numerous chloroplasts along the inner sides. The cells are loosely packed leaving large inter cellular space and respiratory cavities near the stoma. The vascular bundles consist of xylem and phloem. The bigger vascular bundles found to have a sclerenchyma sheath covering completely the vascular bundles or as patches on one or both of the sides.

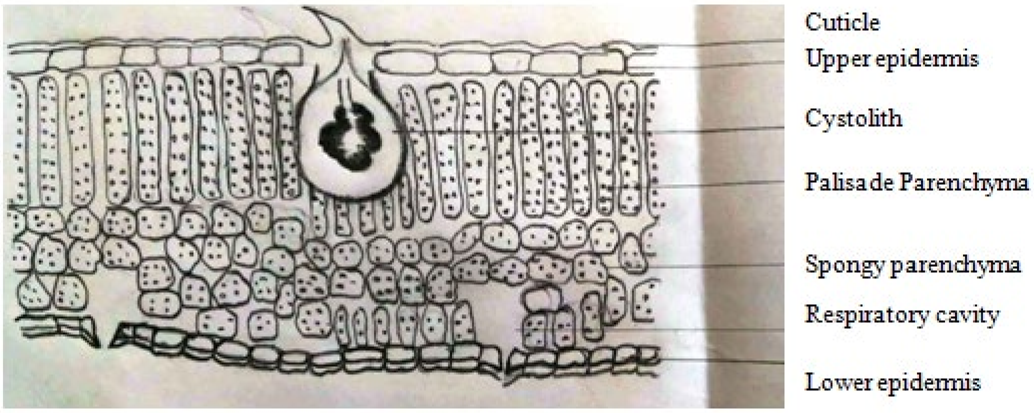


Fig. 2.13. Anatomy of mulberry leaf

SUMMARY

All organisms are composed of cells and some are made up of a single cell while others composed of many cells. However, cells are the smallest form of life and these cells are the functional and structural units of all living things. Cells vary in their shape, size and functions. Based on the presence or absence of a membrane bound nucleus and other organelles, cells and hence organisms can be named as eukaryotic and prokaryotic.

A typical eukaryotic cell consists of a cell membrane, nucleus and cytoplasm. Plant cells have a cell wall outside the cell membrane. The plasma membrane is selectively permeable and facilitates transport of several molecules. All the cell organelles perform different but

specific functions. Centrosome and centriole form the basal body of cilia and flagella that facilitates locomotion. In animal cells, centrioles also form spindle apparatus during cell division. Nucleus contains nucleoli and chromatin network and it also controls the activities of organelles but also plays a major role in heredity.

In accordance with cell theory, cells arise from preexisting cells. The process by which this occurs is called cell division. Any sexually reproducing organism starts its life cycle from a single celled zygote. Cell division is a process which continues throughout its life cycle. Further , the stages through which a cell passes from one division to the next is called the cell cycle and the each cycle is divided into two phases such as Interphase, a period of preparation for cell division and M phase or Mitosis, the actual period of cell division. Interphase is further divided into G1, S and G2 phase.

Basically there are three types of cell divisions such as Amitosis, Mitosis and Meiosis. The Mitosis is divided into four stages namely prophase, metaphase, anaphase and telophase. Mitosis is the equational division in which the chromosome number of the parent is conserved in the daughter cell. The vegetative parts of a plant grow by the process of mitosis. In contrast to mitosis, meiosis occurs in the diploid cells and thereby it reduces the chromosome number by half while making the gametes. The meiosis is divided into two phase, Meiosis I and Meiosis II. Meiosis I has a long prophase, which is further divided as Leptotene, Zygotene, Pachytene, diplotene and diakinesis. Meiosis II is similar to mitosis. At the end of meiosis, four haploid cells are formed. During meiosis crossing over occurs, this genetic phenomenon is mainly responsible for giving rise to 'variations' which is the first step of evolution.

Meiosis is a cytological proof of 'Mendelian law of segregation' and Law of independent assortment. The meiotic pairing of homologous Chromosomes is a clear proof of mixing up of both maternal and paternal characters.

DNA is a major genetic element present in almost all living organisms. It is present in the nuclei of eukaryotic cells and in the protoplasm of prokaryotic cells. In prokaryotic cells, the DNA occurs freely in the form of nucleoid, but in eukaryotic cells, DNA is associated with chromosomal proteins in the form of chromosomes.

Further the mendelian experiments and reasons for success of his experiments are discussed. The Mendel laws such as law of dominance, law of segregation and law of independent assortment were also discussed in detail.

The plants have cells as the basic unit, cells are organized into tissues and in turn the tissues are organized into organs. Different organs in a plant show differences in their internal structure. Within angiosperms, the monocots and dicots are also seen to be automatically different. Internal structures also show adaptations to diverse environments. Basing on this the difference between monocots and dicots were discussed. Further with special reference to mulberry, the anatomy of root, stem and leaf is discussed in the present chapter.

QUESTIONS

Short answer Questions

1. What is cell?
2. Write any two main features of prokaryotic cell?
3. Write a short note on eukaryotic cell?
4. What is Amitosis ?
5. What is Mitosis?
6. What is Meiosis?
7. What is synapsis?
8. What is diakinesis?
9. What is diplotene?
10. What is Crossing over?
11. Write two differences between mitosis and meiosis?
12. What do you mean by dominant?
13. What is Monohybrid Cross ratio?
14. What is Dihybrid Cross ratio?
15. What are Mendels laws?
16. What is interphase?
17. How many type of cell divisions are there?
18. What is genetics?
19. What is the law of dominance?
20. What is the law of segregation?
21. Test Cross
22. Backcross

II. Essay Questions

1. Give an account of Mitosis.
2. Describe in detail about Meiosis.
3. Describe the Mendal's first law of inheritance.
4. Describe the Mendal's Second law of inheritance.
5. What are the major reasons for mendel success?
6. Write in detail about the differences of prokaryotic and Eukaryotic cells?
7. Write various cell organelles and their functions?
8. Draw a labeled diagram of a prokaryotic cell and describe about the cell?
9. Write about the differences between mitosis and meiosis
10. Write briefly the significance of mitosis and meiosis?
11. What are the various stages of meiotic prophase – I and enumerate the chromosomal events during each stage?
12. Write in detail about the anatomy of primary root and secondary root?

Ψ

UNIT 3

Farm Management

Structure

3.1. Introduction

3.2. Factors influencing farm management decisions

3.3. Mulberry Farming

3.4. Raising of mulberry saplings in nursery bed

3.5. Integrated weed management in Mulberry

3.6. Labour Management

3.7. Farm Records

Learning objectives

After studying this unit, students will be able to

- Understand the importance of farming, systems of farming, the factors influencing the farm management decisions and the classification of farming.
- Know the raising of mulberry saplings in nursery bed
- Know the importance and various Integrated Weed Management practices in Mulberry.
- Importance of labour management and positive labour management practices.
- Study and maintenance of different farm records.

3.1. Introduction

In the present scenario, Farm business management has assumed greater importance not only in the developed and commercial agriculture all around the world but also in developing of subsistence type of agriculture. The study of farm management would be useful to impart knowledge and skill for optimizing the resource use and maximizing the profit. A farm manager must not only understand different agricultural production methods but also, he must be concerned with their costs and returns and should know how to allocate scarce productive resources on the farm business to meet his goals. At the same time react to economic forces that arise from both within and outside the farm.

G.F. Warner and J.N. Effersen considered farm management "as a Science of organization and operation of the farm enterprises for the purpose of securing the maximum profit on a continuous basis". Farm management deals with the organization and operation of alarm with the objective of maximizing profits from the farm on a contributing basis. It is necessary to adjust farm organization from year to year. Thus, it is the science which deals with the analysis of the farming resources, alternatives, choices and opportunities within the framework of resource restrictions and social and personal constraints of the farming business which is synthesized to increase profitability of the farming business and to raise the standard of living of the farming people.

Farm management is concerned with resource allocation. On one hand, a farmer has a set of farm resources such as land, labour, farm buildings, working capital, farm equipment etc. that are relatively scarce. On the other hand, the farmer has a set of goals or objectives to achieve increased net farm income and employment generation.

The need for managing an individual farm arises due to the following reasons:

i. Farmers have the twin objectives, *viz*., maximization of farm profit and improvement of standard of living of their families.
ii. The means available to achieve the objectives, *i.e*., the factors of production, are scarce in supply.
iii. The farm profit is influenced by biological, technological, social, economic, political and institutional factors.
iv. The resources or factors of production can be put to alternative uses.

3.2. The factors influencing farm management decisions: Farm management decisions continuously undergo a change because of the changing environment around the farm, farmer and his family. One or more changes in the following categories in the environment around the farmer may cause imperfections in decision-making. The following are the some of the major factors that would influence the decision-making process are:

i) Economic factors like prices of factors and products.

ii) Biological characteristics of plants and animals.

iii) Technological factors like technological advancements in the field of agriculture and suitability of different varieties and farm practices to varied agro - climatic conditions.

iv) Institutional factors like availability of infrastructural facilities which include storage, processing, grading, transport, marketing of inputs and outputs, etc, government policies on farm practices, input subsides, taxes, export and import, marketing, procurement of produces and so on.

v) Personal factors like customs, attitude, awareness, personal capabilities etc.

3.2.1. Systems of Farming

Farming system is a set of agro-economic activities that are inter related and interact with themselves in an agrarian system. It is a mix of farm enterprises to which farm families allocate its resources in order to efficiently utilize the existing enterprises for increasing the productivity and profitability of the farm. These farm enterprises are crop, livestock, aquaculture, agro-forestry and agri-horticulture faming system represent proper combination of farm enterprises *viz*., cropping system, livestock, poultry, fisheries, forestry and the means available to the farmer to raise them for increasing profitability. Cropping system is an important part of a farming system. It represents cropping patterns used on a farm and their interaction with farm resources technology which determine their makeup. But the goal in farming is not to make a profit on same single enterprise or from a part of the farm land but to use land, labour and capital resources in such a way that they make the greatest contribution to the total profits from the entire farm. Farm management helps to identify uneconomical practices and most limiting factors. Farmer as businessman should know (i) how to produce more (ii) how to reduce the cost of production (iii) how to secure high prices for his produce to get more returns by utilizing the resources *viz*., land, labour, capital, managerial ability. Normally the bigger the farm, the greater are the advantages it will have, as on such a farm, capital and labour are most efficiently used and overhead expenses are kept low.

3.2.2. Classification of farming systems

Many farms have a general similarity in size, products sold, and methods followed is called a type of farming or when farms are quite similar in kind and production of the crops and livestock that are produced and methods and practices used in production, the group is called as type of farming. Based on the share of gross income received from different sources and comparative advantage, the farming systems may be classified as follows:

3.2.2.1. The farms are classified based on income or comparative advantages as follows.

a) **Specialized farming:** The income is generated from only one institution to a range of 50 percent or more.
b) **Simple or diversified farming:** In this type, one farm cannot produce 50 per cent income.
c) **Mixed farming:** It is farming on a particular farm which includes crop production, raising Livestock, poultry, Fisheries, Bee keying etc.
d) **Ranching:** There is no cultivation practice and no crop yield. But naturally grown grass utilized to rear cattle.
e) **Dry farming:** In this method, crops are grown entirely under rain fed conditions. It is cultivation of crops in areas where rainfall is less than 750mm per annum. There is no irrigation in this farming. Crop failures are more frequent. Prolonged dry spells during crop period are most common. Mulberry is utilized under rain fed conditions.

3.2.2.2. According to the Water Supply:

i) **Rained farming**: Agriculture mainly depends on the rainfall in most part of the country. 80% of the total cultivated arable land is rain fed. This type of farming is very risky system of farming where the success of the crop depends on the cycle of the monsoon. Timely rainfall is the pre-requisite of this farming. The uneven rainfall is quite unfavorable to crop production.

ii) **Irrigated farming**: The crop can be grown throughout the year; moisture is not a limited factor where continuous water facility is available under the system. Under this method, Production can be increased by proper utilization of productive resources particularly timely irrigation facility.

3.2.2.3. According to the size of the farm

a) **Collective farming**: It includes the direct collection of plant products from non-arable lands. Its either regular or irregular harvesting of uncultivated plants. Honey bee culture and Pisciculture usually go hand in hand with collection wherein actual cultivation is not needed. The natural products like honey, gum, flower etc are collected. Such plant product may be collected from forestry area and from the non tribal forest products.

b) **Cultivation farming**: In this system, farming community cultivates the land for growing crops for obtaining maximum production per unit area.

i) **Small scale farming**: In this type, the farming is done on small size of holding and other factors of production are small in quantity and scale of production is also small.

ii) **Large scale farming**: When farming is done on large size holding with large amount of capital, large labour force, large organization and large risk are called large- scale farming. The factors of production are large in quantity and the scale of farming is said to be large.

3.2.3. The familiar Faming systems in India

The variation in types of farming in India is largely due to climatic difference. Depending on the periodic monsoon makes irrigation a problem in many areas of the country. Based on the climate and water availability, the following types of farming are existed in India and each having its own unique features.

1. **Irrigation Farming**: This type of farming system relies on an irrigation system supplying water from a river, reservoir, tank, or well. Water is becoming more and more crucial as there is an increasing demand for food.
2. **Shifting cultivation:** Under this cultivation system, cultivate one plot of land for a particular period of time until the soil becomes infertile. As crop yield decreases, the plot is deserted, and the ground is re-fertilized using the slash and burn technique. This method is popular in the north-east and the east coast of the country largely among the tribal communities. It is used to cultivate rain-fed rice, corn, buckwheat, millet, root crops and vegetables
3. **Commercial Agriculture:** Commercial agriculture systems involve large-scale plantation such as those used for wheat, cotton, sugarcane, tea, rubber and corn. The

yields are exported to other countries for a profit.

There are three types of commercial agriculture systems such as

i) **Intensive commercial farming:** With small landholdings and a high population, many farms use a lot of manpower on a relatively small piece of land.

ii) **Extensive commercial farming:** This is the opposite of intensive commercial farming. A small workforce is applied to a large piece of land. Cultivation depends on mechanical methods.

iii) **Plantation agriculture:** A plantation is a large piece of land within an estate where the crops are cultivated and sold internationally.

4. **Ley Farming:** This type of farming is used to restore soil fertility in India's drylands. A plot of land is used for grain or other crops and when the soil starts to degrade, the land is left uncultivated. It is used to grow hay or as a pasture for grazing animals. After several years, it can be used for crops again as the nutrients are restored by ploughing. Land erosion during the ley period is also prevented by the roots of the grass.

5. **Plantation Farming:** It is popular for its large-scale cultivation of one crop on an estate or vast property. This system is designed to make a profit and as such requires all technology and techniques be efficient. Tea, coffee, and rubber are all commonly-grown on plantation farms.

6. **Crop Rotation:** This system is a type of subsistence farming. Usually, there are one or more farmers responsible for the labour and the produce is for their own consumption. A crop rotation schedule includes different varieties of crops such as wheat, barley, mustard or millet being grown during alternating seasons. The benefits are that weeds, pests and diseases are controlled while soil fertility is maintained.

7. **Co-operative Farming**: Cooperative farming systems in India have only recently appeared and the aim is to combine land resources and farmers so as to benefit everyone. In India, there is a huge potential to build on this method. The families are attached to their land and unwilling to give it up and to share in a co-operative system as the farmers fear that they will lose their jobs.

3.3. Mulberry Farming

Mulberry is a hardy perennial and high biomass producing plant which can be grown under different agro-climatic conditions. The plants are responding well to optimum agricultural inputs. Under assured irrigation and appropriate fertilizer application, the leaf can be produced up to 30,000 kg/acre/year. Due to insufficient rain, water availability is the major concern, so which mulberry cultivation is not encouraged under rainfed conditions. However, mulberry is cultivated like other crops under irrigation farming. For effective growth of mulberry, the optimum temperature of 20 - 30°C and relative humidity of 65 – 80 % is ideal. The most common method of propagation of mulberry in tropical region is by asexual means such as Stem cuttings, Grafting and Layering. Among these methods, propagation through stem cuttings is simple and most cost effective.

Mulberry grows in a wide range of soils and better growth is obtained in loamy to clayey loam soils. Soil testing is very important before taking of plantation. Based on the soil analysis, reclamation measures need to be taken up. The mulberry plant can tolerate slightly acidic conditions in the soil. Acidic soils with pH below 5, necessary reclamation measures through application of lime can be corrected. In case of alkaline soils, application of Gypsum should be resorted for correction of the soil alkalinity. The preparation of soil, and plantation methods have been studied in the previous year. However in the present chapter, the nursery preparation methods have been explained.

3.4. Raising of mulberry saplings in nursery bed

In any perennial crop, initial establishment plays an important role in subsequent growth and yield, mulberry is no exception. In commercial cultivation, the mulberry garden is generally established through stem cuttings. However, due to variation in soil, moisture status, fluctuations in temperature and non-adoption of recommended methods of planting by farmers, the initial establishment is not always satisfactory having large number of gaps. As an alternate method, planting saplings is found to be advantageous. The saplings ensure successful establishment of garden. To raise these saplings, selection of land, preparation of land, cutting preparation and planting the cuttings in the nursery is of vital importance.

Selection of land: Flat or slightly sloppy land is suitable for raising hard wood. Plough land up to 30 to 45 cm. deep by tractor, power tiller, bullock plough or manually before the onset of monsoons. Plough the land 2-3 times to bring soil to a fine tithe and free of weeds. Land should be leveled before preparing of raised nursery beds and remove stones if any.

Land Preparation for raising nursery: Select the nursery plot which is free from nematode and Root rot. Nursery beds should be preferably located close to a water source. Select elevated, flat, well drained light textured, deep loamy or clay loamy soil. The land has to be thoroughly ploughed 30 – 40cm deep and allowed to weather in the sun for 2 – 3 weeks. Later it must be repeatedly ploughed 2 – 3 times to bring the soil to fine tilth. Root stocks, stones, pebbles and weeds should be thoroughly removed at the time of ploughing.

The nursery beds are to be prepared in a convenient size of 300 x 120 cm (Length and width). Irrigation channels of 25-30 cm width and 15-20 cm depth are made in between two rows of nursery beds. Apply FYM/ Seri-compost/ Vermicompost @ 20kg/ nursery bed and the manure must be incorporated into the soil through light digging.

Preparation of cuttings: High yielding variety of mulberry to be chosen for planting. The seed material from 6-8 months old shoots with 3-4 active buds (pencil thickness). The cutting should be free from tukra infestation and scale insect. Ensure the plot does have only the selected variety, always prepare the seed cutting from middle portion of the shoot. Do not damage buds and cut ends while preparing cuttings and it can be used as planting material to establish the mulberry saplings. Sprinkle water if transplantation is extended/postponed or delayed. Transport the mulberry cuttings during cooler hours of the day to avoid drying and desiccation. Prepared cuttings, if required to be stored, should be bundled with all buds in one direction and kept in wet sand bed with the buds pointing upwards under shade.

Planting Techniques: The nursery beds should be adequately watered one or two days prior to planting of cuttings. Each row is marked keeping a distance of 20 cm with the help of rope. Cuttings are dipped in fungicide like 0.2 % Dithane-M-45 solution for 10-15 minutes to prevent mortality in nursery. Provide 20 cm spacing between rows and 8 cm between cuttings. A bed size of 300 cm (L) x 120 cm (B) accommodates 180 cuttings to raise 4 months old saplings. To raise 6 – 8 months old saplings, the same bed with the distance between row to row 30 cm and cutting to cutting in a row 10 cm distance accommodates 100 cuttings. Make holes with a stock in the soil to insert cuttings. Plant the cutting in slant position. Ensure exposure of one active bud in each cutting. Press the soil firmly around the cuttings. Do not disturb the cutting after plantation as it would affect sprouting and survival rate. Cuttings of reduced rooting ability varieties can be dipped for 6hrs in root promoting hormones Naphthalene Acetic Acid (NAA) / Indole Butyric Acid (IBA)with a concentration of 200 ppm for better rooting. Each bed on all sides is separated by a bund of 25 to 30 cm width and height and provided with irrigation channel of 25 to 30 cm width and 15 to 30 cm depth.

Irrigation: After plantation of cuttings, immediately one irrigation should be given, there after based on the soil condition and dryness of the nursery beds frequent irrigation or minimum once in a week during dry period to be given. In case of sandy loamy soils, irrigation to be given once in 4 – 5 days and 6 to 7 days in black soils.

Fig. 3.1 Nursery plantation

Fig. 3.2 Sprouting of cutting in the nursery

Maintenance of mulberry nursery: The nursery beds must be kept free from weeds. At least two times of weeding is required, first after 25 – 30 days and second after 55 to 60 days. At the age of 55-60 days saplings in the nursery, apply 500gm ammonium sulphate or 250gm urea dissolved in the irrigated water for each bed. Apply cow dung slurry along with irrigation as organic manure for healthy growth of sapling.

Disease and pest management in the mulberry nursery: The most common disease noticed in nursery is leaf spot for which application of 0.1% Bavistin twice at an interval of 15 to 20 days is recommended. For control of Tukra, spraying of 0.1% DDVP is suggested. Spray of 0.1% Bavistin against powdery mildew and 0.1% Rogor againstthrips and mites is advised.

Uprooting of sapling for plantation: After four months of growth period and formation of root system, saplings will be ready for transplantation. Good saplings attain a height of 90 to 120 cm in 3 – 4 months and about 150 cm in 5 to 6 months in nursery bed. Irrigate the nursery beds prior to uprooting. Uproot the saplings with a spade or pick-axe. Sprinkle with water in case delay in plantation for uprooted saplings. Pack the sapling in convenient size with wet gunny bag to avoid desiccation of roots if long distance transportation is required.

Plantation of saplings: It is advisable to take up plantation during onset of monsoons with saplings. The advantages are as follows.

1. The planting material requirement is less per unit area, one sapling per pit, where as cuttings are planted two per pit.
2. Plant establishment/ sprouting takes less time than cutting.
3. Plants grow uniformly and vigorously.
4. Number of branches and leaf are more.
5. There will be quick and better root proliferation.
6. Plants can be trained easily which is suitable for bush and tree plantation.
7. Rearing can be taken up early than the seed cutting plantation.

Fig. 3.3 Plantation with saplings in main field

Fig. 3.4 Sprouting of saplings

Various mulberry plantation methods have covered / studied during first year.

For large scale supply of newly developed mulberry variety to the farmers, seed material is distributed to raise the kissan nursery. It is a viable commercial proposition to raise saplings on large scale and make them available to farmers during planting season. Saplings can be raised directly in flat / raised nursery beds. The saplings so raised in the kissan nursery can be sold to the needy farmers. It is quite useful and profitable venture for the farmers to establish kissan nursery and grow as an entrepreneur.

3.5. Integrated weed management in Mulberry

Growing of mulberry is the first and foremost pre-requisite for successful sericulture. Weeds are unwanted and undesirable plants, which interfere with the utilization of land and water resources and thus adversely affect plantation. The common weed flora that are noticed in mulberry gardens are *Cyperusrotundus*L. *(sedges), Cynodondactylon Pers. (grasses), Parthenium hysteroporus*Linn.*, Euphorbia geniculata* (broad leaf weeds). Weed competition for nutrients has been reported the most serious factor in limiting crop yields. Weed competition in mulberry cause considerable yield loss depending upon weed flora, density and duration of weed infestation. To obtain satisfactory yield levels, mulberry need weed-free conditions for initial 30-45 days after planting. The age-old practices of weed control in mulberry gardens such as hand weeding and digging is tedious, time consuming and expensive. In such circumstances, integrated weed management is an ultimate alternative for effective control of weeds which could be more economical.

Integrated weed management (IWM) means integrating multiple methods to manage weeds, using the combination of practices that is most effective for solving the specific weed issue at hand. For the success of any weed management programme, adoption of adequate preventive measures is a pre-requisite.

IWM is the control of weeds through a long-term management approach, using several weed management techniques such as, Physical control, Chemical control, Biological control and Cultural control. Any integrated weed management plan or strategy should focus on the most economical and effective control of the weeds and include ecological considerations.

Weed management:

A plant not sown in the field or growing where it is not desired is called weed. These weeds are harmful, interfere with the agricultural operations, increase labour input, add to the cultivation cost and also reduces the crop yield. Depending upon the degree of competition, weeds reduce the crop yield in the range of 10 – 15% in different crops. It is quite effective approach involving all the possible methods, Physical, chemical and biological methods was more effective than individual methods for the control of weeds.

During the initial stage of plant establishment in the field, weed growth should be kept to the minimum, so that the growing young plants are not restricted by the weeds. At least two weedings should be carried out during the first six months after planting of cuttings, once after two months of planting and again after an interval of 2 to 3 months. The weeding operation should be thorough, and the soil should be dug deep to remove the weeds with roots. This deep digging is carried out as part of the weeding operation and results in necessary loosening of the soil and a stimulation to the plants to grow vigorously. Thus, special care should be taken to reduce the weed growth as much as possible in the first year of planting. Thereafter, the shade effect of the fully-grown mulberry will tend to keep the growth of weeds down. Similarly, periodical inter-cultivation should be resorted to particularly in the case of dry mulberry gardens during the first year so that soil loosening results in better aeration and stimulation of plant growth. This also helps in catching the rain water and its deep penetration for better retention of soil moisture.

3.5.1. Physical control: It is the removal of weeds by physical or mechanical means, such as mowing, grazing, mulching, tilling, burning or by hand. The method used often depends on the area of weeds to be managed, what the land is used for, physical characteristics and the value of the land. It is important that, when using physical control, any item that can move from a weed-infested site to an un-infested site, such as machinery, vehicles, tools and even footwear, is cleaned free of weed seed before moving, to stop the spread of weeds to new areas.

The long-term suppression of weeds requires the following up weed prevention procedures.

i. ***Hay making, mowing and grazing:*** Hay making, mowing and grazing before weeds produce seeds restrict the amount of weed seed in an area and reduce the spread of weeds.
ii. ***Mulching:*** Mulching, by covering the ground with a layer of organic material, suppresses or kills weeds by providing a barrier between the weeds and sunlight.
iii. ***Tilling:*** It is nothing but the ploughing or cultivation method that turns over the soil, buries the weed beneath the soil. This provides a barrier to the sun, therefore killing the weeds. Tilling is a form of physical control that can be easily undertaken over a wide area, using agricultural machinery.
iv. ***Burning:*** It removes the above-soil body of the weeds killing most of the plants. If carried out before seed is set it can prevent the further spread of weeds. Burning can be undertaken over a wide area with minimal human input.
v. ***Hand removal:*** Removal by hand, including hoeing, is a good method for selective removal of weeds without disturbing the surrounding desirable vegetation.

3.5.2. Chemical Control: Although the use of chemicals is not always essential, herbicides can be an important and effective component of any weed control program.In some situations, herbicides offer the only practical, cost-effective and selective method of managing certain weeds. Because herbicides reduce the need for cultivation, they can prevent soil erosion and water loss, and are widely used in conservation farming.

In some cases, a weed is only susceptible to one specific herbicide and it is important to use the correct product and application rate for control of that weed. In most cases, weeds must be actively growing to be vulnerable to herbicide treatments. Herbicide resistance can also be an issue with some species. Conditions such as wind speed and direction, the possibility of rain and proximity to waterways should also be taken into account when preparing to use herbicides.

In mulberry cultivation, under chemical control it is advised spraying of Glyphosate, post emergence, non-selective, systemic and translocative herbicide. Immediately after pruning, spray @0.71 % concentration, 600 liter of spray solution per hectare on the weeds. Two applications per year (1^{st} and 3^{rd} crops) are ideal for effective management of weeds.

3.5.3. Biological Control: It is generally defined as action of plants, predators or pathogens in maintaining another organism's population at a lower average than would occur in their absence. This is often natural populations are regulated by a variety of natural enemies such as insects and pathogens (disease-causing organisms like fungi and bacteria) that attack the seeds, leaves, stems and roots of a plant. If plants are introduced to a new region that does not have these natural enemies, their populations may grow unchecked to the point where they become so prevalent that they are regarded as weeds. This method is advantageous over the chemical method as it is cheap, environmentally safe and would be a permanent solution.

Cultural Control: Cultural control is usually associated with farming systems, although some elements are relevant to landscape and bush care practices. It largely involves manipulating farming practices to suppress weed growth and production, while promoting the development of the desired plant. Encourage the competitiveness of desired species that are more competitive and fast growing. This suppresses weed growth by reducing access to available sunlight, nutrients and moisture.

Manual inter-cultivation / tillage or use of herbicides is the commonly adopted methods in different crops. However, it is difficult to control the perennial weeds like *Cyperus rotundus*, C*ynodon dactylon*, etc. by tillage or manual inter-cultivation, which propagate through underground parts like tubers and rhizomes. Herbicides though have given good results, are not full proof. Further adoption of biological control measure which gained momentum is also not fully effective. Thus, in the recent years adoption of integrated approach has gained prominence.

In mulberry, manual inter-cultivation conducted during each crop is mainly aimed at removal of weeds. It is one of the expensive cultural operation in mulberry cultivation. Despite repeated intercultural operations, the weeds like *Cyperus rotundus and Cynodon dactylon* appear in each crop in high density. These cause immense crop loss. Though ploughing is more economic method of intercultural operation, but does not ensure weed removal from the fields, in fact these weeds get buried in the soil during overturning. These weeds again establish and compete vigorously with the crop during sprouting stage and the activity also leads to spread of weeds in the field. To overcome the weed menace, application of herbicide (Glyphosate) is suggested. Immediately after pruning, the said chemical is sprayed (@0.71% concentration, 600 liter of spray solution / ha). Two applications per year is ideal for effective weed management.

Thus, adoption of appropriate weed management system is must to keep the weeds below threshold level of infestation in order to avoid mulberry crop loss. Adoption of integrated method is new trend of weed management in mulberry which needs to be popularized.

3.6. Labour Management

Farm / agriculture work is of a different type and the nature of work depends upon the season. There may not be fixed work hours and no guaranteed work all through the year to everyone. Unlike urban industries, there is no standardization and specialization of work. The farm labour consists of farmer's own labour, his family labour and hired labour. The Indian farmer is himself a farm manager and a labourer. Further his family members are also engaged on his own farm, where wages are not paid. This free labour is called as family labour of the farmer. The hired labour may be permanent, temporary, casual or contract labour. The woman involved in permanent labour stay on the farm and the farmer can employ them wherever needed. Further these are given preference over the casual labourers who are engaged on daily wages for various seasonal operations. Sometimes seasonal operations like weeding, harvesting, land development work like digging of pits or channels, construction of bunds etc., are carried out by engaging contract labour. Certain agricultural practices like sowing, transplanting, harvesting have shortage of labour and wages also go up considerably. During unseasonal period, plenty of labour are available. At such times, works like bunding, farm development, roads, drain are to be taken up.

3.6.1. Classification of labour: The labour is classified based on the wages as following.

i) **Free labour:** It includes farmer, his family members who work without wages. This is also an income to the farmer and doesn't require any supervision.

ii) W**age labour:** In this permanent, temporary, casual and contract labour are included. Some of these labour are familiar with farm techniques and some doesn't require it

3.6.2. Wages: The wages paid to the working people in agriculture are of three types and the wages are based on time, place and capital share. According to "Wage Regulation and Minimum Wages Act 1948" the labour wages are to be decided based on the physical status of labour, concentration in the work, utilization of implements, type of implements, natural conditions *i.e*., cold, rain, temperature and the technical knowledge of the labour.

3.6.3. Labour Efficiency: Labour efficiency is the amount of productive work done in the agriculture farm. The labour efficiency largely depends on the labour himself *i.e.* health, capacity to work, experience, skill and interest. Other factors like tools, equipment and implements handled by him, health of bullock, seasons, size of fields, fertility and general conditions of the field also effect the efficiency of labour.

3.6.4. Measures in Labour Management: Farm efficiency can be improved by fulfilling the needs of labour. Employer should take care of proper wage payments, health supervision, child welfare.

i) Prepare a calendar depending on the season, crop to engage labour. Labour is engaged depending on the type of cultivation practice and the employer should think properly before implementing.

ii) Family members are engaged when there is no work. Labour should not keep idle. If there is no work in the farm, they are engaged in other way to repair farm implements, to clean the farm house and to look after farm animals.

iii) During rainy days waged labour needs to be engaged only when it is required.

iv) Selection of crop, cropping methods, utilization of farm animals reduces the labour.

v) The Farm Manager must be efficient to utilize the labour in a proper way.

vi) Usage of efficient implements and machinery and proper attention to their repairs and servicing is also important.

vii) Daily working hours are adjusted as per season *i.e.,* in summer season, start the work very early, while in winter it may be started late.

viii) Specialized labourers are employed from such communities who are known for their expertise and efficient work.

ix) Beside this, the efficiency of labour depends on proper farm management, supervision, training of labour, provision for various facilities, selection of good implements, incentive wages, to keep on certain standards to each farm work, regular payment of wagesto finish the work in proper time.

x) The qualities of farm manager also add to the efficiency of labour, the qualities such as personal working knowledge of the work, personal influence, tactfulness, appreciation of labourers work, not having frequent changes in work, firm but sympathetic or considerable attitude towards the labourers help in getting better output from the labourers. One should remember that a labourer is not a machine, but a human being and proper human approach is necessary. A farm manager should remember that a highly paid efficient labourer is cheaper for hard or intelligent work, while a low paid inefficient laborer is in fact costly for such items of work.

3.6.5. The Positive Farm labour management practices identified in the workplace for better work efficiency are as follows.

a. **Respectful treatment:** It involves a broad range of issues including positive communication styles, direct grower-worker communications, a healthy work environment and decision-making structures that recognize the contribution and value of each employee.

b. **Fair Compensation:** It is one of the most important one as the fair compensation rates paid to the farm workers influences work efficiency.

c. **Year-round employment:** The provision for year-round employment as one of the conditions that the farm workers give most value, after good wages and respectful treatment. The year-round work enables employees to maintain a stable family life, yielding benefits for their children and communities.

d. **Traditional benefits:** Traditional benefits include paid time off, life insurance, and free or subsidized housing. Farm employees rely on benefits to supplement what they earn by wages. Access to benefits can greatly improve the health and well-being of farm employees and their families.

e. **Non-traditional benefits:** Non-traditional benefits include a broad range of innovative strategies to help employees and their families. Due to language barriers, documentation status and economic constraints, farm employees often don't have access to many of the public services and institutions. Employers can help to connect employees with valuable service providers, or at times, provide some of those services themselves.

f. **Safe and Healthy Workplace:** The highest and most important product of the farm is the workers health, safety and happiness.

g. **Direct hiring & Recruitment:** By practicing direct hiring and recruitment, growers can have greater control over product quality.

h. **Team based management structures:** A democratic, team-based approach to management and supervision can successfully motivate employees and result in significant cost savings.

i. **Open communication and decision making:** There are a range of practices that foster good communication between employers and employees, such as safety meetings, employee orientations and employee handbooks, are focused on communicating information and expectations. Others, such as regular meetings and grievance procedures, provide opportunities for worker representation and participation in decision-making processes.

j. **Opportunities for professional development:** A provision for formal and informal opportunities for employees to gain new technical or managerial skills through Hands- on- training, formal education etc.

3.7. Farm Records: Agriculture occupies a prominent position in Indian economy. Agriculture is very important source of income for the people in the country. For any business, suitable, quick and reliable information plays an important role for the different kinds of decision making. Secondary nature of information in farming business plays a critical role in decision making. Farmers are less interested in the record keeping of the business. In farming business, farmers deal with the different components of expense like plantation, fertilizer, irrigation, plant protection, harvesting, transportation and other miscellaneous expenses as well as with the revenue of the farming business. The farmers are getting very thin margin for their business. With concern to any business, if the person does not maintain their business records properly, then it would be very difficult to keep track of each event and transaction of the business during a time period. The output of the farm record keeping process is a kind of information on which, a person can take proper decision about their business.

A farm record is a document (in most cases a book) that is used to keep account of different activities, events, materials etc. regarding the farm operations. Farm records are different from farm accounts in the sense that farm accounts deal only with the financial aspects of all farm operations. Farm accounts deal majorly with the farm expenditures and income and help the farmer to calculate how his business is doing.

It is always said that Indian cultivator is good producer rather than good business man. He knows how to produce but he does not know how to keep accounts of the farm. It is therefore, very necessary to have enough knowledge about farm accountancy in order to handle the farm business efficiently. The farm accounting or accountancy is also called as "Farm Book keeping".

3.7.1. Advantages of Registers

1. It is a base for identification of needs and to implement.
2. To improve the efficiency of farmer.
3. Basis for management and loaning.
4. Acts as a compass for management.
5. Scope for farm research for further improvement.
6. Basis to take proper decisions.
7. Useful for steady development of farm.

3.7.2. Problems in maintenance of registers

1. Small scale farm maintenance.
2. In most of the situations, farmer himself is a labour, manager and owner.
3. Illiteracy is a problem for maintenance, lack of awareness on latest techniques.
4. Complicated nature of agriculture industry and maintenance of records are not simple.
5. Fear about taxes.
6. Lack of awareness on nature of registers.

3.7.3. Different Farm Records

Mulberry farm maintenance and silkworm rearing have prominence in sericulture. The quality of cocoons depends on mulberry leaf quality. The cocoon crop is totally depending upon the mulberry crop. Thus, mulberry crop is grown with sufficient irrigation, manuring, pruning methods, inter-cultivation, pest management, besides good management skills. The following registers help the farmer to get good crop results.

1. **Daily farm records/ Work Register**: These are the records of important daily activities and events that happen on the farm. These records help the farmer keep track of past farming activities and plan for future activities.

   It is useful in utilization of labour in the maintenance of mulberry garden and several cultural operations. The efficiency of labour can be assessed based on man days utilized for each cultural operation. The work turned out on each day and the work attended for each plot could be assessed.

2. **Records of farm implements and equipment**: This is used to keep an inventory of all the equipment on the farm and their quantity. It can also contain the date of purchase of the equipment and sometimes their description.

3. **Record of agricultural inputs:** This record is used to keep track of all agricultural inputs such as fertilizers, seeds, etc. The record often also contains the amount of that was bought, the amount that has been used, and what is left.

4. **Records of livestock and livestock products**: Farmers keep different records of livestock for each type of livestock on the farm. The livestock that have products, eggs from chickens, the farmer keeps a record that accounts for the number of eggs laid every day. If a farmer has cows for milk production, he keeps record of the number of litres of milk produced per day.

5. **Records of animal feeds:** This record is used for keeping an inventory of the types of animal feed and the quantity purchased, used and quantity in stock on a daily basis.

6. **Production records**: Production records are used to document everything that is produced on the farm. These records are prepared every week and then summed up at the end of the month and at the end of the year. Thus, there is a weekly record, a monthly record, and an annual record of everything produced on the farm. They help the farmer to keep track of how well the farm is doing.

7. **Records for farm use:** It is used for recording the date the land was prepared for farming, the number of plots or hectares used in planting, the plants planted on the farm and where they are planted.

8. **Farm expenditure records**: Farm expenditure records are used to keep a record of all expenditures.

9. **Workers records:** This type is used to keep the record of staff, their salaries and payment of salaries or wages. It is also known as labour record.

10. **Vehicle records:** It is used to keep a record of all vehicles used on the farm, fuel and oil used and also any repairs and servicing and the dates of the repair or servicing.

11. **Sales record:** Sale records are used to keep a record of all sales made from farm produce.

12. **Meteorological record:** Temperature and rainfall have a great impact on the productivity of mulberry leaves. The daily record of maximum and minimum temperatures and rainfall should be recorded as a ready-reckoner.

These records are necessary to manage the farm well. It helps the manager to know whether the farm is giving profits or not. However, in sericulture the registers such as Work register, Nominal register, Inventory register and Meteorological registers are quite useful for documentation. These records show certain important facts such as yield of different crops and livestock, the dates of various farm operations, labour details, increase or decrease in capital, annual receipts and expenses from which profits or losses for the different activities and the farm for the year can be worked out. It will help to locate the weak points in farming practices and show the ways of strengthening them. The farmer can plan the future programme on the facts that have been recorded and can work out the cost of cultivation of major crops and think about amendments, if any.

SUMMARY

- *Farm business management has assumed greater importance not only in the developed and commercial agriculture all round the world but also in developing and subsistence type of agriculture Adoption of scientific and technical methods to improve farm products.*

- *Farm management deals with the organization and operation of a farm with the objective of maximizing profits from the farm on a contributory basis.*

- *Farming system represents proper combination of farm enterprises viz. cropping system, livestock, poultry, fisheries, forestry and the means available to the farmer to raise them for increasing profitability.*

- *Farm management helps to identify uneconomical practices and most limiting factors.*

- *Farming systems can be classified based on income, water supply and size of the farm.*

- *Farm management decisions continuously undergo a change because of the changing environment around the farm, farmer and his family.*

- *The most common method of propagation of mulberry in tropical region is by asexual means such as Stem cuttings, Grafting and Layering. Among these methods, propagation through stem cuttings is simple and most cost effective.*

- *The saplings ensure successful establishment of garden. To raise these saplings, selection of land, preparation of land, cutting preparation and planting the cuttings in the nursery is of vital importance.*

- *The age-old practices of weed control in mulberry gardens such as hand weeding and digging is tedious, time consuming and expensive. In such circumstances, integrated weed management is an ultimate alternative for effective control of weeds which could be more economical.*

- *Integrated weed management (IWM) is the control of weeds through a long-term management approach, using several weed management techniques such as: Physical* *control, Chemical control, Biological control and Cultural control.*

- *In any farm management, labour management is of crucial and needs to be handled strategically to maximize the work efficiency.*
- *The Labour are classified into free and wage labour and the wages are three types based on time, place, and capital share.*
- *Labour efficiency is the amount of productive work done on the farmer labour and there are many managerial skills to improve the efficiency of labour. The quality of farm manager also adds to the efficiency of labour.*
- *Farm records help the manager to know whether the farm is giving profits or not.*
- *There are many advantages of farm records but problems encounter in maintenance.*
- *By keeping the farm records, helps to locate the weak points in farming practices and show the ways of strengthening them.*
- *The farmer can plan the future programmes on the facts that have been recorded and can work out the cost of cultivation of major crops and think about amendments, if any.*

I. Short Questions

i) Mention different types of farms.
ii) Write about the procedure involved in preparation of cuttings?
iii) Write about the Factors Influencing the Farm Management Decisions?
iv) Mention farm systems.
v) What are the classes in labour?
vi) Why farm records are essential to a farmer?
vii) Mention different type of farms
viii) What is free labour and hired labour?
ix) Differentiate permanent and contract labour.
x) How do you improve labour efficiency?
xi) What is integrated weed management?

II. Essay Questions

1. Write in detail about systems of farming?
2. Write an essay on integrated weed management in mulberry?
3. Describe the procedure involved in establishment of mulberry nursery?
4. Write about various farm records and describe them?
5. Write a note on the Positive Farm labour Management Practices?
6. Write about the measures in labour management.
7. Write short notes on
   a) Farm systems b) Types of farms c) Farm record uses

5. Write short notes on
   a) Labour wages b) Problems in maintenance of records c) Ranching

6. Write short notes on
   a) Labour management b) Classification of Labour
   c) Labour efficiency

Practice

- Establishment of mulberry nursery.
- Visit to different Farms of nearby villages and observe the functioning of farms.
- Observe various labour management strategies during your visit to nearby villages.
- Discuss with the sericulture farmer about weed management which is being followed by him.

Ψ

UNIT 4

Mulberry Diseases

Structure

Objectives

After reading this, you will be able to

- Understand the types of mulberry diseases.
- Identify the foliar diseases through symptoms.
- Identify the root diseases through symptoms.
- Know the deficiency symptoms of the mulberry.
- Manage the deficiency symptoms in mulberry cultivation.

4.1. Introduction

Mulberry is a fast growing plant and leaf contents are rich in protein, sugar and moisture and mulberry is not an exception to diseases. The nutritional value of leaf however, varies greatly due to several factors among which the diseases play an important role. The mulberry being a perennial crop the pathogens seem to rapidly develop and quickly spread to cover extensive areas. Certain alternate and collateral hosts (weeds) play some role in continuation of some of the pathogens.

Disease is one of the limiting factors for quality mulberry leaf production and the success of silkworm crop depends on the quality of mulberry leaves fed to silkworms. Disease is an abnormal condition that results due to some micro or macro organism which causes disturbance in physiology. The repeated pruning of mulberry at an interval of about 70 days in the same field favours the survival, multiplication and inoculum buildup of certain foliar and soil borne pathogens causing several diseases. The mulberry diseases are caused by bacteria, virus, fungi, and parasitic nematodes. These diseases affect the growth of mulberry and cause considerable damage to the plant and loss in leaf yield. However, these pathogens do not pose any serious threat to mulberry cultivation in general. The diseases of mulberry are either airborne (foliar) or soil borne (root) in nature and reduce the leaf yield up to 20 % and the quality of the leaf also greatly affected. There are various types of diseases of they get affected in roots, stem and leaves and the area of attack varies depending on the type of disease. They show lot of diversity in disease symptoms. Environmental factors like temperature, humidity and rainfall plays an important role in spread of mulberry diseases. Feeding of diseased leaves affects the growth and development of silkworm, cocoon yield and silk quality. Sometimes, complete failure of cocoon crops and reduced marketing quality of cocoons produced. Hence, close observation; timely control measures and regular monitoring are essential for management of mulberry garden to ensure quality leaf production.

Based on the plant parts affected, the diseases are classified as foliar, root, vascular and systemic diseases. The diseases appearing on leaf and stem are known as foliar diseases. When the disease appears on the root system is termed as root disease and the disease spreading throughout plant system is called systemic disease.

4.2. FOLIAR DISEASES OF MULBERRY

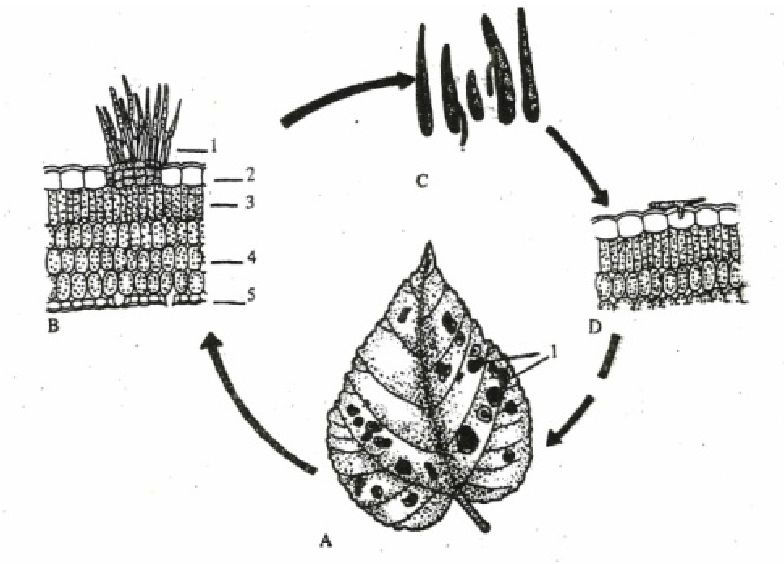
The diseases affective the above ground parts of a plant are termed as foliar diseases. As the leaf in mulberry is the basic food for silkworm, the damage caused is both in terms of leaf yield and quality is a great concern.

4.2.1. LEAF SPOT DISEASE

Causative organism: It is caused by ***Cercospora moricola,*** a fungal pathogen.

Occurrence: It is an air-borne disease occurring during rainy season followed by winter. The disease starts 35 – 40 days after pruning / leaf harvesting and becomes severe after 70 days. The leaf yield is reduced to 10-30 per cent.

Disease Cycle: Spread of fungal spores (conidia) primarily through rain droplets. The fungus produces a compact mass of interwoven cushion like hyphae, which produce conidiophores. These once again turn to produce 3-7 celled conidia. Conidia are hyaline, tapering at one end and 70 x 3 mm size. These conidia can produce new hyphae from any cell. It takes about 10-12 days after inoculation of conidia to produce a spot and another 3-4 days for forming conidia.



a) Affected Mulberry leaf
b) T.S. of infected leaf
c) Conidiophores
d) Germinating conidia on the leaf surface

Fig. 4.1. Disease cycle of Leaf spot

Symptoms: The diseased leaves have several circular or irregular brownish spots of varying sizes. These spots become enlarged and lead to **'shoot holes'.** Severely affected leaves become yellowish and fall prematurely. Diseased leaves are not suitable for feeding silkworm.

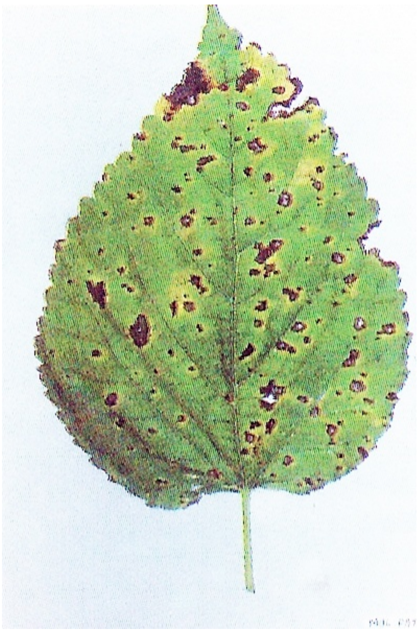


Fig.4.2. Leaf spot affected mulberry leaf

Control measures:

- Follow w ider spacing of plantation (90cm × 90cm) or paired row planting system [(90cm + 150 cm) × 60cm] should be followed.
- Spraying 0.2 % Bavistin (Carbendazim 50% WP) solution on the mulberry leaves.

4.2.2. POWDERY MILDEW

The disease is caused by ***Phyllactinia corylea,*** a common and dangerous fungus belongs to class Ascomycetes.

Symptoms

- It is most common in the rainy or post rainy season and more prevalent in hilly areas. It spreads very rapidly through wind. The disease results in a net leaf yield loss of about 40 per cent. The protein content of harvested leaves in diseased plants is reduced to 30 per cent.

- The disease prevails during winter and rainy seasons progressing from 40th day after pruning or leaf harvest and becoming severe on 70th day after prunning . Temperature of 24 - 28ºC and high relative humidity (75-80 %) are ideal for the infection and disease development.

- White powdery patches appear on the lower surface of the leaves. The corresponding portions on the upper surface of leaves develop chlorotic lesions. On severity of the disease, white powdery patches turn to brownish-black; the leaves become yellow, coarse and lose their nutritive value.

Fig. 4.3. Mulberry leaf affected with powdery mildew

Disease Cycle

This is an ectoparasite, absorbs nutrients by sending haustoria into the epidermal cells through the stomata. The pathogen reproduces by both sexual and asexual methods. A sexual reproduction takes place by conidia. Conidia are hyaline, unicellular and club shaped measuring 70x20nm. Conidia are formed terminally on separate conidiophores. The liberated conidia disperse through wind current and finally spread the disease. The mycelium is unbranched hyaline and forms a mycelial mat sticking to the leaf surface.

Sexual reproduction is by formation of fruiting bodies known as *cleistothecia.* These are covered with numerous colourless needle shaped appendages. These are 5-50 asci inside the *cleistothecium* which on maturity liberated during favourable conditions. Each ascus has two ascospores which germinate to produce hyphae, spreading the disease.

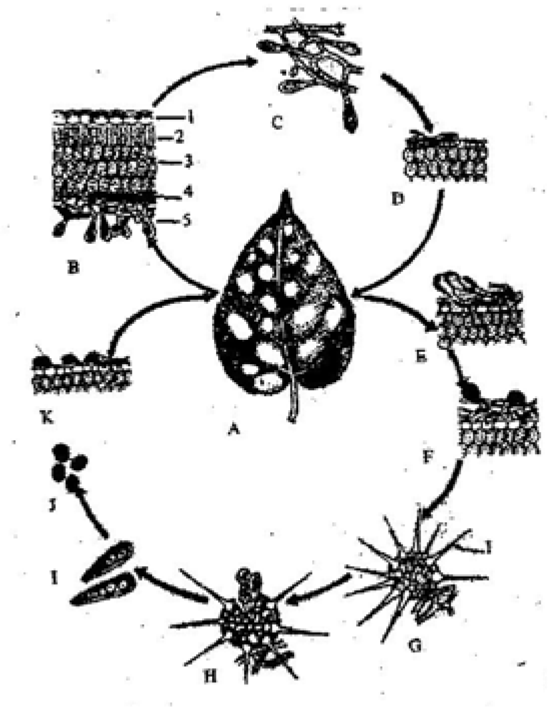


Fig.4.4. Disease cycle of Powdery mildew

a) Affected Mulberry leaf
b) T.S. of infected leaf
c) Mycelia and Conidia
d) Germinating conidia.
e) Ascogonium and Antheridium
f) Young cleistothecium
g) Matured celistothecium
h) Liberation of Asci
i) Ascus
j) Ascospores
k) Germinating ascopore
1. Upper epidermis
2. Palisade tissue
3. Spongy tissue
4. Lower epidermis
5. Mycelia with conidia

Control measures:

- Wider spacing of plantation or paired row planting system should be followed.
- Spraying of 0.2 % Karathane (Dinocap 30% EC) / Bavistin on the lower surface of the leaves.
- Cultivation of mildew resistant varieties like MR1 and MR2.

4.2.3. LEAF RUST DISEASE

In India, *Cerotelium fici* is the causal agent of Leaf Rust which is a fungal pathogen belonging to class basidiomycetes.

Symptoms: It is the one of the dangerous leaf disease and the mature leaves are more prone to the disease. It leads to leaf loss of 10-30 per centbesides deteriorating the leaf quality. The disease is prevalent during winter and rainy seasons. It is an obligate parasite and microcyclic rust and starts progressing 45-50 days after pruning becoming severe on 70 days after pruning. Temperature of 22-26°C and high relative humidity above 70 % are ideal for disease development. The pathogen produces numerous pin head size circular to oval brownish to black eruptive lesions on the lower surface of the leaf. In advanced stage the leaves become yellow and fall off prematurely.

Fig. 4.5. Leaf rust affected mulberry leaf

Disease Cycle

It is a microcyclic fungi exists primarily as mycelium, uredium and uredospore. Uredospores are oval to round, uninucleate produced singly on uredospores and uredia. These germinate to form hyphae which enter the leaf through stomota. The hyphae grow intercellularly in the host tissue, extending haustoria into the host cells to collect nutrients. Uredospores are spread through water droplets and wind and the disease severity increases with the age of leaf.

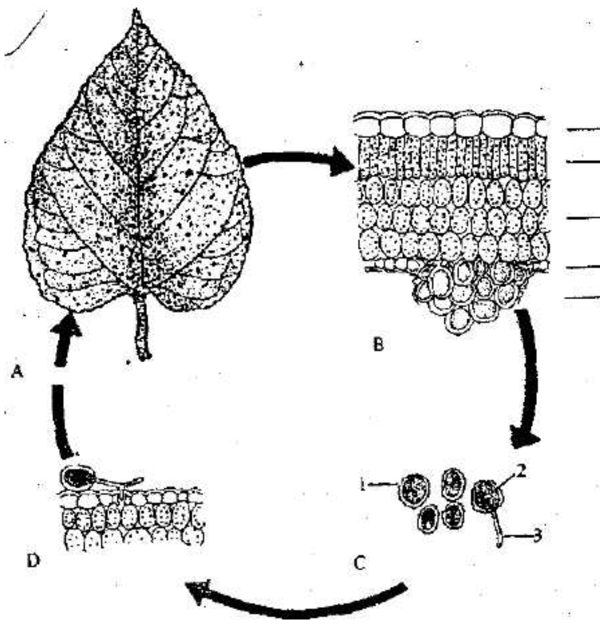


Fig. 4.6. Disease cycle of *Cerotelium fici*

a) Mulberry leaf infected by leaf rust
b)T.S. of infected leaf
c) Liberate Uredospores
d) Germination
1. Upperepidermis
2. Palisade tissue
3. Spongy tissue
4. Lower epidermis
5. Uredospore

Control

- Timely utilization of leaves without delaying the leaf harvest during winter season.
- Wide spacing of plantation to reduce the disease incidence.
- Spraying of fungicides like Carbendazim / Chlorothalonil at 0.2 per cent concentration (2 grams of chemical per litre of water) reduces the disease severity and the safe period to use the leaf is 15 days.
- Cut and burn the diseased mulberry leaves and shoots.

4.2.4. LEAF BLIGHT DISEASE

Both fungi as well as bacteria cause leaf blight in mulberry. The fungal leaf bight is prevalent mainly in tropical regions whereas bacterial blight is worldwide in occurrence.

4.2.4.1. Bacterial Leaf Blight or Bacterial leaf spot

The disease is caused by a bacterium *Pseudomonas syringae* pv. *mori* / *Xanthomonas campestris* pv. *mori and it is more prevalent in India.*

Symptoms: Numerous, small, irregular, water-soaked patches can be seen on the lower surface of leaf margins. These spot later grow bigger and change to brown colour. Then leaves become curled and rotten. The affected patches fall of prematurely and appear like torn in wet weather. But in dry weather remain dry on the intact leaf. The veins and vein lets, petioles are also infected. Black longitudinal lesions are also seen on the bark of the young shoots.

It is more prevalent during rainy and winter seasons. It starts progressing 35 days after pruning and becomes severe on 70th day after pruning and reduces the leaf yield up to 5-10% besides deteriorating the leaf quality. Higher temperature (28 - 30ºC) and humidity (more than 80%) are favourable for disease development.

Fig.4.7. *Mulberry leaf afftected with Bacterial leaf blight*

Control

- The diseased plants should be rooted out or burnt to reduce the inoculum load in the garden.
- Closer spacing plantations are to be avoided.
- Foliar spray of 0.1 per cent concentration (1 gram of chemical in 10 litres of water) of streptomycin or streptocycline.

4.2.4.2. Fungal Leaf Blight

It is caused by *Alternaria alternate / Fusarium pallidoroseum* is prevalent during summer and rainy seasons and starts progressing 45 days after pruning and becomes severe on 70th day after pruning. The disease reduces the leaf yield up to 10-12% besides deteriorating leaf quality. Dispersal of fungal spores (conidia) occurs by water and wind currents. Temperature of 25-30º C and relative humidity of 40-60 % are favourable for the outbreak of fungal blights.

Symptoms: The disease appears as browning/ blackening of leaves from tips or margins of leaf. The preliminary symptoms appear in the form of isolated irregular brown coloured patches. As the disease spreads the entire leaf surface is affected resulting in fall of leaves.

Fig. 4.8. Mulberry affected with fungal leaf blight

Control

- Wider spacing of plantation or paired row planting system should be followed.
- Spraying of 0.2 % Dithane M-45 (Mancozeb 75 % WP) on the leaves.

4.2.5. Mosaic disease : It is caused by viruses transmitted by grafting or insect vectors.

Symptoms: The green part around the veins is lost and mosaic, dark and green patches appear on the leaves. Then the leaves show inward curling especially leaf margin and tip with chlorotic lesions on the leaf surface. This result, a reduction in plant height and leaf size, sometimes these are reduced to half size than healthy ones. The leaves loss nutrient value and physical features

Disease Cycle: It spreads primarily through infected plants. Once the virus is inside the susceptible host tissue; it becomes systemic. The incubation period varies from 7-25 days. Depending on the climate and host pathogen relationship the disease symptoms may be expressed or masked. This disease is common during rainy season.

Control: Uprooting and burning of diseased plants. Removal of old plants before planting, washing the hands and tools with a disinfectant to prevent the transmission. It is also advised to select only virus free plant material for grafts and cuttings.

Fungicides and their uses

Chemicals used for control of fungal diseases by killing causative fungi are called fungicides. The fungicide is a mixture of active ingredient (a.i.) and inert material. The active ingredient in a fungicide is the chemical. Each fungicide is having two names viz., trade name and common name. The manufacturing company gives a product name for the fungicide for sale and is termed as trade/commercial name. The common name indicates the presence of actual chemical in the product. For example Bavistin is a trade name and common name for this fungicide is Carbendazim 50 % WP. If Bavistin is not available in the market, any other product having the chemical (active ingredient) Carbendazim can be used. Common name of the fungicide also indicates the available form and percentage of active ingredient in the formulation *viz*., solid/ liquid, Wettable powder (WP) / Emulsifiable concentrate (EC). Almost all the fungicides are poisonous, but the degree of toxicity differs. The degree of toxicity is indicated on the pack by a triangular mark in different colours *viz*., red/ yellow, blue and green. The red/yellow mark indicates the presence of higher amount of poison, blue colour indicates the moderate amount and green colour indicates negligible amount of poison in a particular fungicide. In case where a new fungicide is being tested and safe period for feeding of leaves to silkworms is not known, the tentative safe period could be determined by observing these triangular marks on the products.

- Fungicide pack having the red/ yellow mark - safe period is 15-20 days
- Fungicide pack having the blue mark - safe period is 5-7 days
- Fungicide pack having the green mark - safe period is 3-5 days

Precautions to be taken while spraying the fungicides

For effective and safe use of fungicides, the following precautions need to be taken.

- Do not allow children and persons having wounds for spraying.
- Wear protective devices such as goggles, gloves and apron during spraying.
- Do not mix the fungicide by hand and always use rod/stick for mixing.
- Do not blow the nozzle with mouth and use needle for cleaning.
- Choose cool hours (early morning or late evening) for spraying.
- Do not spray during rainy days and against the wind.

Preparation of the spray solution: For preparation of 0.2% solution, the quantity of chemical required is 2 g/ml per litre water and one acre mulberry garden about 150-180 litres of spray solution is required. The spray needs to be given 40-45 days after pruning/leaf harvest during cool hours (early morning or late evening). If the disease is not controlled second spray should be given 10-15 days after the first spray. The fungicide sprayed leaves can be fed to the silkworms after 4 days of spraying.

Table 4.1. Mulberry leaf diseases, symptoms and their control measures

Sl.No.	Name of the disease	Symptoms	Season	Control measures
1	Leaf spot	Brownish black spots with yellow border.	Rainy	Spray 0.2 % of Bavistin (2 g/ lt) twice with an interval of 10 days
2	Leaf Rust	Rust like brownish black spots.	Winter	Spray 0.2 % of Kavach or Captofol twice at an interval of 10 days
3	Powdery mildew	White powdery patches on the lower surface of leaf.	Winter & Rainy	Spray 0.2 % of Bavistin (2g / lt)
4	Leaf blight (Fungal)	Marginal blacking followed by complete burning & defoliation.	Summer & Rainy	Spray 0.2 % of Capton and drench the soil with 0.2 % Dithane M-45
5	Leaf blight (Bacterial)	Blackish brown watersoaked patches followed by curling and rotting of leaves.	Rainy & Winter	Spray of 0.2 % Dithane M -45 (2g/ litre). 100 ppm streptomycin (1g / 10 litres)
6	Mosaic disease (Viral)	Green part around the veins is lost and mosaic, dark and green patches appear on the leaves. the leaves show inward curling and tip with chlorotic lesions.	Rainy	No suitable control measures are available. Affected plants may be uprooted and burnt.

4.3. ROOT DISEASES OF MULBERRY

Diseases of the root system cause serious problems for mulberry cultivation in standing crop as well as during nursery plantation. These diseases are caused by soilborne pathogens, which affect the root system and general health of the mulberry plant. The major root diseases are Nursery diseases, Root knot, Root rot & Disease complex.

4.3.1. NURSERY DISEASES: During preparation of the stem cuttings, various wounds are inflicted. These wounds form the entry points for many soil borne pathogens causing various diseases during nursery plantation of the cuttings. Stem canker, cutting rot, collar rot and die back are the major diseases affecting mulberry during nursery stage. Temperature of 28-30ºC, soil moisture below 40 % and soil pH of 5 - 10 are most favourable for the disease development. Stem canker and Cutting rot are affected during sprouting of the cuttings, where as the diseases like Collar rot and Die back attack the saplings. The mortality of the saplings is up to 35-40%.

a. **Stem canker:** The disease is caused by the fungus, *Botryodiplodia theobromae.* It is characterized by the presence of greenish-black eruptions on cuttings and the bark decays and dies.
b. C**utting rot**: It is caused by the fungus, *Fusarium solani.*The disease appears as decaying of bark and then rotting of whole cutting resulting in death of the sprouted cutting
c. **Collar rot**: It is caused by the pathogen, *Phoma mororum* or *P. sorghina.* The disease appears as brown or black discolouration of bark and rotting of cuttings near the soil.
d. D**ie-back**: It is due to the pathogen, *Botryodiplodia theobromae.* It is characterized by the wilting of saplings from the tip downwards resulting in death of the saplings.

Fig. 4.9. Stem canker Cutting rot Collar rot Die-back

Control measures

Chemical method: Soak the cuttings in 0.1 % Dithane M-45 solution for half an hour before plantation and these cuttings are to be planted in nursery beds followed by irrigation.

Integrated management: The method involves the dipping of cuttings in Dithane M-45 (0.1%) solution and application of bioformulation called as Nursery guard prepared by using *Trichoderma pseudokoningii*. This has to be applied by mixing 1 kg of Nursery-Guard with 60 kg FYM which is sufficient for 2000 cuttings. The mixture should be stored under the shade for one week by adding 10 - 12 litres of water. After one week, this mixture should be broadcasted in nursery beds @ 2 kg/m^2 and mixed well in soil. For direct plantation of cuttings in main field, the Nursery guard mixture should be applied in pits @ 50 g/pit before plantation.

4.3.2. ROOT KNOT DISEASE: It is caused by *Meloidogyne incognita*, a nematode an endo-parasite. It a serious soil – borne disease occurs throughout the year especially in sandy soils under irrigated conditions. Temperature from 20-30 ºC, soil moisture of more than 60 % and pH of 4-8 are favourable for the development of the root knot disease reducing the leaf yield up to 15% besides deteriorating the leaf quality.

Symptoms: This disease is more prevalent in summer and the parasite causes alternation in plant physiology. The affected plant shows stunted growth, marginal necrosis and yellowing of leaves. The underground symptoms are formation of characteristic knots or galls on the roots. The young, spherical and yellowish white galls appear on roots. Old galls are big and pale brown in colour. They are often mistaken with root nodules. Root galls are bulging of roots at different places and root nodules appear on the root surfaces. Small knot indicate single infection and large one multiple infections. The parasite damage xylem and phloem tissues resulting in disruption of water and food conduction

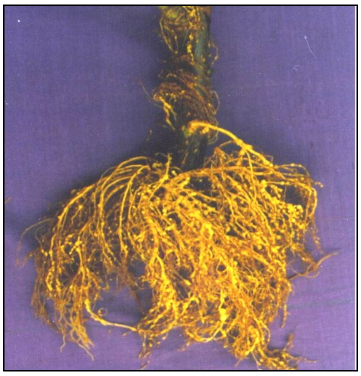
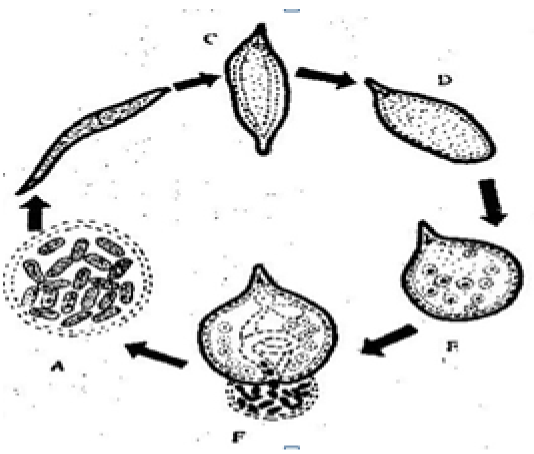


Fig. 4.10. Mulberry affected with Root knot disease

Disease Cycle: It consists of three stages in life cycle i.e. egg, larva and adult. The second stage of female larva found in soil, enters the root through the hole made by style and settle in sub epidermal layer. It feeds on parenchymatous tissue. It also stimulates the plant cells to undergo repeated division leading to enlargement forming cankerous knots/galls on the roots. Female larvae undergo four moults to become adult. Each female lays 200-322 ellipsoid eggs covered with gelatinous material. Eggs hatch larvae and are liberated into soil under favorable conditions. It takes 30-40 days to complete life cycle. It can repeat life cycle 2-3 times in its life span. The soil temperature 15-30°C and moisture 40-60 per cent encourage parasite growth. The nematode infestation is more in irrigated mulberry farming.



A.Eggs with in gelatinous matrix
B.Second stage infective larva
C. Larva with hemispherical and terrainate spike
D. Female completed moults
E. Typical female

Fig. 4.11. Disease life cycle of *Meloidogyne incognita*

Control measures

a) **Physical and cultural method:** This parasite can be controlled by deep ploughing or digging of infested garden during summer to expose nematode eggs and larvae to direct scorching sun rays. Further mulching, application of green manures, compost, oil cakes (neem) to control the infestation. Using of disease free saplings for new plantation and if the saplings are having root knot symptoms, treat them with hot water (48°C for 20 minutes) before plantation. Further planting of marigold (*Tagetus patula*) as inter crop at a distance of 30 cm in between mulberry rows.

Neem oil cake @ 2 MT/ha/yr in 4 split doses should be applied around the plant during fertilizer application/ cultural operation.

b) **Chemical method:** Application of Furadan (Carbofuran 3 G) @ 40 kg/ha/yr in 4 split doses should be applied during fertilizer application/cultural operations and the safe period is 45 days. Neem oil cake/Furadan should be applied to the soil around the plant mixed thoroughly by ploughing/digging followed by irrigation.

c) **Integrated management:** It involves the soil application of **Bionema** prepared by using *Verticillium chlamydosporium* / *Trichoderma harzianum* after mixing with neem oil cake and FYM (1:24:200). 1 kg Bionema should be mixed with 24 kg neem oil cake and 200 kg FYM and stored under the shade for about one week by adding 30-32 litres of water (sufficient for 1000 plants). Roots of infected plants should be exposed by digging about 5 cm depth. Bunches of knots of roots should be cut and burnt. The prepared mixture should be applied @ 200 g/plant around the exposed roots (3 times/year at an interval of 4 months) during cultural operations/fertilizer application followed by irrigation.

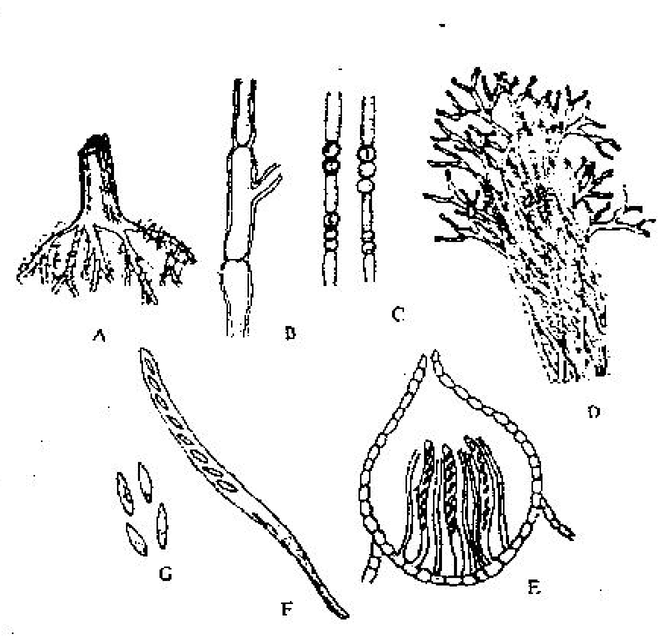
4.3.3. ROOT ROT DISEASE: Root rot, due to its epidemic nature and potential to kill the plants, is a dangerous disease of mulberry. It is widely distributed in almost all the sericultural areas and mainly caused by the fungus *Rhizoctonia bataticola* (Macrophomina phaseolina) and other microbes such as *Fusarium solani*, *F. oxysporum, Botryodiplodia theobromae* etc. The disease is very serious in mulberry growing areas of southern India. The disease occurs throughout the year in all types of soils especially when the soil moisture and organic matter are low. About 15 % loss is estimated due to the disease.

Generally there are two types of root rot diseases *i.e.* white and violet root rot.

4.3.3.1. White root rot disease: It is caused by the fungal pathogen ***Rosellinia necatrix*** belongingto the class Ascomycetes.

Symptoms: The diseased mulberry plants become weak, feeble growth of leaf buds, withering of leaves, weak growth of plant and the plant dies very soon. The stump region of the affected plants is covered with whitish-gray mycelial mat, which is a characteristic symptom.

Disease Cycle: The fungus reproduces asexually by forming chlamydospores, sclerotia and conidia. Under favourable conditions it reproduces sexually by asci and ascospores inside perithecium. Each asci has eight ascospores. The hyphae emerge from different spores infect the primary roots and later spreads to the whole shoot system causing white root-rot. The sclerotia and sexual spores remain as resting spores in the soil, dried root and stump parts in unfavorable conditions and perpetuate e disease in favorable condition causing plant death.



a) Mycelia on the root surface
b) Mycelium,
c) Chlamydospores,
d) Inter woven mycelia with conidia,
e) Perithecium,
f) Enlarged ascus with ascospores,
g) Ascospores.

Fig. 4.12. Disease cycle of White root-rot

4.3.3.2. Violet root-rot : It is caused by the fungus *Helicobasidium mompa* belonging to the class Basidiomycetes.

Symptoms: Leaves wither off and plants collapse during rainy season. The epidermal tissue of roots are covered with violet coloured mycelial mat. As the disease advances the rooting spreads to the xylem tissue also.

Disease Cycle: The hyphae are purplish, septate, terminating with fructification bodies called basidia. Each basidia has four basidiospores at the top; Basidiospores rapidly germinate in wet soils and rain drops and the hyphae enter the new root system and spread disease. The germinating spore becomes the nutritive hyphae. Under unfavorable conditions the mycelia form the sclerotia or the hardened masses of hyphae. They remain for a long time on the dead root tissue and germinate on return of favorable conditions. This pathogen can also live in many other host plants and perpetuate indefinitely.

Fig. 4.13. Above ground symptoms of rootrot

Fig. 4.14. Below ground symptoms of root rot

Control measures to be adopted

(a) Physical/Cultural method: The dead plants should be uprooted and burnt immediately. The uprooted area should be heated by burning with dry leaves and grasses. Sufficient quantity of organic manure should be applied to the affected soil. The infested land should be ploughed deeply and exposed to sun for effective killing of the pathogens.

(b) Chemical method: As soon as the initial symptoms like wilting/withering of leaves appear on plants, Dithane M-45 should be applied around the root system @ 10 g/plant after removing the soil from the infected plants to a depth of 15 cm. If the disease is very severe, the affected plants should be uprooted and destroyed. Dithane M-45 @ 10 g/pit should be applied in the diseased pit and the new sapling should be treated with 0.1 % Dithane M-45 solution. It has also to be applied surrounding plants of the diseased patch. Four doses of Dithane M-45 should be applied in a year at an interval of 3 months for effective control.

(c) Integrated management involves the application of Dithane M-45 integrated with biofungicide, Raksha (*Trichoderma harzianum*). The diseased plants should be uprooted and burnt. 10 g of Dithane M-45 / pit should be applied and the new saplings should be planted after soaking in Dithane M-45 (0.1%) solution for 30 minutes. It also should be applied to the surrounding plants of the diseased patch. After 15-20 days, the Raksha mixture should be applied @ 500g/plant in the root zone of the plant followed by irrigation. Raksha mixture is prepared by mixing 1 kg Raksha with 50 kg FYM (for 100 plants) and stored under shade for one week by adding 8-10 litres of water. Application of Raksha should be continued for one year at an interval of 3 months. Raksha does not show any residual toxicity on both mulberry and silkworms.

Navinya application: A target specific new formulation *Navinya* was developed especially for the control of root rot disease in mulberry, which composed of plant derivatives (80%), organic (8%) and inorganic (12 %) chemical compounds.

Method of Navinya Application: Prun the affected shoots to base of the stump above 15-30 cm from ground level. Make shallow ring around stump to prevent overflow of the solution mixture. Prepare solution of Navinya by adding 10 gm in 1 liter of water and stir well (1 kg Navinya in 100 liter; sufficient for 100 plants @ 1 liter/plant). Pour the solution over the pruned stump to drench completely up to the ground level. Cover with soil to prevent degradation from sunlight and escape of gases. Treat the surrounding mulberry plants also to prevent the spreading of the disease.

Precautions to be taken:

i. Do not irrigate the treated mulberry plants during the first 4-5 days.
ii. Remove the dead mulberry plants and burn and expose the soil to sunlight.
iii. Plant the new saplings after dipping their roots in 0.2 % Navinya solution for 30 minutes before planting.
iv. Treat plants showing symptoms such as blackening the leaf and withering the shoots immediately to save from dying.
v. Maintain optimum organic content >0.5% in soils by applying compost manure.
vi. During summer months irrigate the garden to keep the soil moisture around 60-70% to prevent the disease.

4.4. Macro and Micro Nutrient deficiencies and control

4.4.1. Nitrogen symptoms: Nitrogen, Phosphorous and Potassium are the macro elements required by the plant and some micro elements also required for its luxuriant growth which are present in soils in little quantities and sometimes its deficiency causes some abnormalities leading to crop losses. So supplementation of above macro and micro nutrients give rise normal growth to plants. It shows retarded development of roots, reduction in size of the branches, slow and weak growth of plants with less branches/vigour. Stunted appearance of the plant indicates deficiency of soil nitrogen. Young leaves show chlorosis. Stem is slender and yellowish green with stunted root growth.

The nitrogen is an important nutrient for plants accounts for about 1-4 per cent of the dry weight of the plant. It also forms a biological constituent of all proteins, enzymes, chlorophyll, vitamins, hormones and nucleic acids. It is essential to increase the content of water in plant tissue and decreases the percent of calcium in them. The critical level in the soil below which deficiency symptoms occur for mulberry is 18 lb/acre when the nitrogen is in the form of nitrate and 65lb/acre when it is in the form of ammonia.

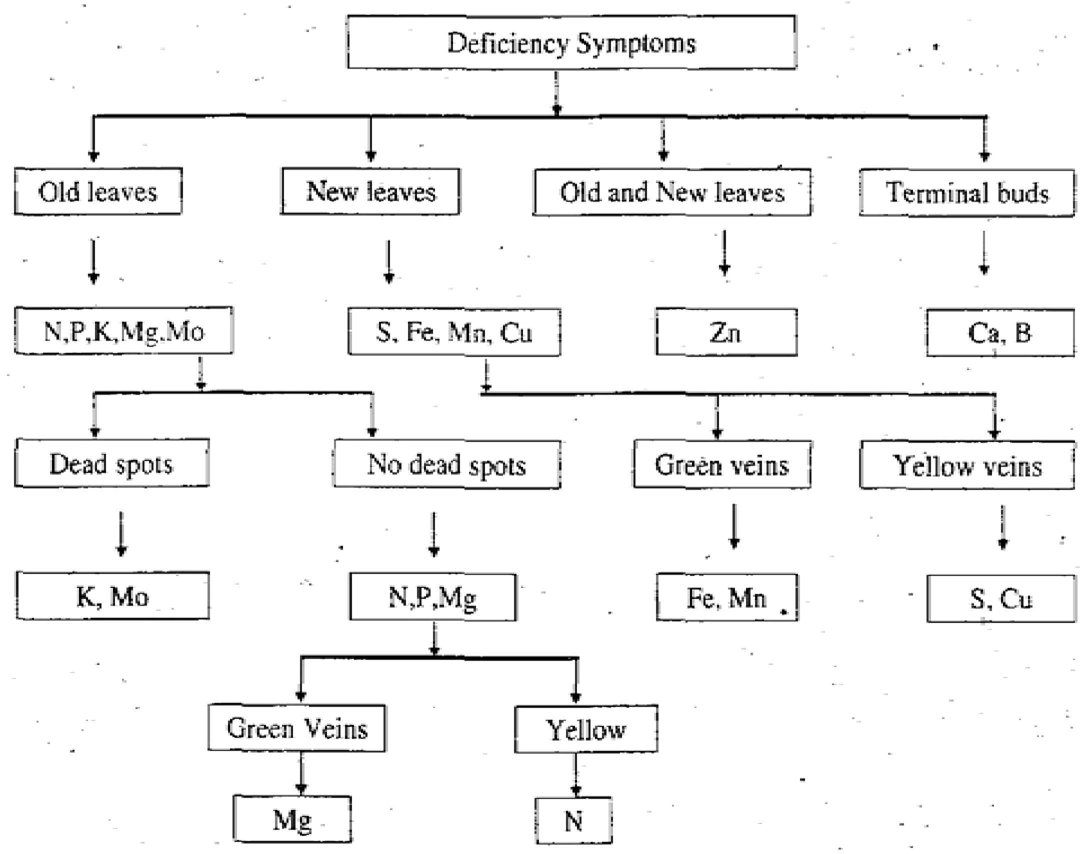


Fig. 4.15. Identification of deficiency symptoms

4.4.2. Potassium symptoms: Deficiency lead to weakening of stem and root systems. The young leaves become small, show marginal scorching and later become coarse, non-juicy, necrotic when they mature. It also causes intra-veinal chlorosis, retards photosynthesis.

The plant may not show good growth even if other elements are available in the soil. This element moves freely, do not form any structural component of the plant, but exists in free-state as a cation. It activates many enzymes, regulation of the stomodeal closure mechanism, photosynthesis, cell hydration, synthesis of carbohydrates and protein and catalyzing nitrate reduction. Its role is important to promote thick outer walls in the epidermal cells and tissues which resist collapse.

In West Bengal the common mulberry disease is controlled by using potassium though exact cause is still unknown. The leaves show rusty brown patches and are deficient in potash, protein and sugar contents. The diseased leaves are poisonous to silkworms and cause flacherie disease.

4.4.3. Phosphorus symptoms: The deficient plants show chlorosis of older leaves. The chlorosis spreads throughout the leaf and this is followed by marginal necrosis and defoliation. The stem will be slender without fresh growth and the root system becomes stunted. The decoloration of the stem and leaves to reddish or purplish colour.

This element is a component of nucleic acid, protein and phospholipids' and necessary for metabolic activity. It strengthens the stem and prevents the lodging of the plant. It influences plant vigour, crop quality, resistance against diseases. The minimum level of phosphorous required for mulberry growth is 50-65 1b/acre.

Micro elements

4.4.4.Calcium Symptoms: It causes defoliation of young leaves with necrosis along the veins and later stages leads to abscission of the leaves. The leaves become pale. The plant show stunted growth with woody stem with yellowish tips. The roots become stubby and dry.

Calcium is an important element of all plant cell membranes and concerned with its permeability. This element controls cell division and formation of cell wall, by its presence in the middle lamella. It promotes the activities of soil bacteria to form nitrates from organic nitrogen and to fix atmospheric nitrogen. It also promotes good root system. It reduces the harmful action of iron and manganese to the plant roots. Plants grow in calcium enriched soil, when subjected to moisture stress, lose their water slower than those grown in ordinary soil. Thus calcium is an efficient element for plant.

4.4.5. Sulphur Symptoms: It results in slight chlorosis of leaves with subsequent abscission, abnormally long and woody stem and roots finally leading to arrest of growth. Sulphur is necessary for the synthesis of some amino acids, enzymes and vitamins and also formation of chlorophyll. When sulphur is oxidized to sulphates, soil becomes acidic and growth and survival of some bacteria and fungi in the soil are discouraged.

4.4.6. Zinc Symptoms: The deficiency of Zinc exhibits in the young leaves inter venial and yellowish spots on leaves. Irregular shaped leaves, short inter nodal distance giving a bushy appearance to the plant.It regulates the activities of the enzymes involved in the formation of IAA the natural growth hormone. It is necessary for synthesis of protein, nucleic acid and carbohydrates. It regulates stem elongation and cell enlargement:

In addition to the above said, many other trace elements may also be necessary for the healthy growth of mulberry plants. These minerals support good vegetative growth of quality and quantity of leaves and building resistance to diseases and pests. A close and methodical observation, timely supply of required mineral elements and proper cultural practices prevent the occurrence of deficiency diseases and boost the quality and quantity of leaf produced by the crop which can be utilized to feed silkworms to get good quantity and quality of cocoons.

4.5. Prevention and control measures of nutrient deficiency

Nitrogen: Application of nitrogenous fertilizers like urea, ammonium nitrate, potassium nitrate or calcium nitrate at appropriate doses is recommended for correction.

Potassium: Application of potassium fertilizer is useful in curing the element deficiency.

Phosphorus: This deficiency can be cured by phosphorus fertilizers like triple phosphate or superphosphate.

All these are corrected by sufficient supply of NPK to the soil at a proper time.

Calcium: Liming the fields with requisite amount of lime which corrects the deficiency. Application of calcium nitrate also serves the purpose.

Sulphur: Application of gypsum or ammonium sulphate at appropriate dose is recommended for correction. Factampose (15%) or Zinc sulphate (15%) can also be used.

Zinc: Application of zinc sulphate at appropriate dose for correction of this element is recommended. Further soluble zinc salt or zinc chelates or zinc sulphates can also be used.

Summary

- *Disease is an abnormal condition that appears due to an organism causing disturbance in physiology.*
- *Foliar and soil-borne disease pose serious threat to mulberry in many areas under cultivation.*
- *The disease causing organism incidence varies with seasonal factors, mulberry varieties and cultivation practices.*
- *Disease to mulberry plant causes leaf loss, leaf quality, plant death.*
- *Bacteria, virus, fungi, parasitic nematodes cause diseases.*
- *To manage the foliar diseases effectively, the recommended fungicides should be sprayed twice during the crop period at 0.2% concentration and leaves should be utilized after the specified safe period.*
- *Stem-canker, cutting rot, collar rot and dieback, affect the initial establishment and survivability of mulberry plantation in nursery.For managing the root diseases ,the recommended integrated eco-friendly methods have to be used for better control.*
- *Leaf blight (bacterial disease) shows small, numerous, irregular water - soaked patches on the ventral leaf surface.*
- *Fungal diseases are common in mulberry.*
- *Powdery mildew appears as white powdery patches on the lower surface of the leaf.*
- *Leaf rust affects mostly mature leaves causing 10-30% loss.*
- *Root rot causes rotting of root and sudden withering of leaves forming white or violet mycelial mat on the root.*
- *Twig blight causes marginal blackening or burning of leaf.*
- *Stem disease form cankers on the stem.*
- *Nematode forms knots or galls in the root.*
- *Plant growth depends on the nutrient availability in soil.*

- *The deficiency symptoms appear clearly in crops with larger leaves.*
- *The region of appearance of deficiency symptoms depends on mobility of nutrient in the plant.*
- *Mulberry shows deficiency symptoms due to the non-availability of different mineral elements.*
- *Nitrogen shows chlorosis and stunted growth of stem and it could be corrected with application of nitrogen fertilizers.*
- *Potasium causes stem and root weakness, causes marginal necrosis and leaf becomes coarse, non-juicy and necrotic and it could be corrected by application of potasium fertilizers.*
- *Phosphorus causes intra veinal chlorosis of older leaves. De colorization of stem and leaves also occur. Its deficiency is corrected by phosphorus fertilizers.*
- *Calcium deficiency causes defoliation of young leaves with necrosis along the veins, can be cured with calcium nitrate.*
- *Sulphur cause slight chlorosis of leaves and corrected with gypsum.*
- *Zinc shows intra veinal and yellowish spots on leaves and deficiency is corrected by application of zinc sulphate.*

QUESTIONS

I. Short questions

1. What are the soil-borne diseases of mulberry?
2. Name any three leaf diseases of mulberry?
3. Mention some fungal diseases of mulberry?
4. What are the diseases that attack during nursery plantation?
5. What are the symptoms of mulberry leaf spot?
6. What are symptoms of leaf blight?
7. Mention causative for powdery mildew disease?
8. What do you mean by root knot ?
9. What is the causative organism of root rot?
10. What is stem canker?
11. What is the damage caused by nematode?
12. What are causes for leaf rust?
13. What are the causes for stem canker?

14. Which leaves show deficiency symptoms?
15. Mention some plant nutrients.
16. What are the control measures of nitrogen deficiency?
17. What are the control measures of phosphorus deficiency ?
18. What are the characters of Zinc deficiency?
19. What are symptoms of copper deficiency?
20. What are symptoms of potash deficiency?
21. What are the symptoms of sulphur deficiency?

II. Essay Questions

1. Describe leaf spot disease with neat diagrams.
2. Write detail account on root- knot disease with diagrams.
3. What is white root rot? Explain?
4. Explain about leaf blight disease?
5. Describe powdery mildew disease?
6. Write short notes on
   a) Stem-canker b) Leaf rust c) Leaf spot
7. Write short notes on
   a) Powdery mildew disease b) Root knot c) Root rot
8. Explain in detail about deficiency symptoms of plant nutrients?
9. How do you identify the root knot and root rot diseases and write about their management?
10. Write in detail about both the leaf blight disease affected by bacteria and fungi?

Ψ

UNIT 5

Mulberry Pests

Structure

Objectives

After reading this unit, students will be able to

- Know the important pests attacking mulberry
- Understand the symptoms of pest attack and period of occurrence.
- Know the various management procedures of pest attack.
- Evaluate the effectiveness of control methods.
- Learn preparation of required pesticide concentration.
- Understand the concept of IPM

5.1. Introduction

Mulberry is the only food plant of the silkworm, *Bombyx mori.* The activities associated with production of mulberry (*Morus* spp.) leaf is often hampered due to interference caused by several insect and non-insect pests during cultivation. The insect which is causing damage to plant is called pest. The important pests such as Mealy bug, leaf roller, Grosshopper, Jassids, Thrips, Cutworm, Bihar hairy caterpillar, Whitefly, Scale insect, Stem borer, termites etc. The problems posed by pests are of high magnitude, especially in the premier silk producing states like Karnataka, Andhra Pradesh and Tamil Nadu where mulberry cultivation and silkworm rearing activities are carried out throughout the year. In these states, mealybug and leaf roller are the two major pests which impose appreciable qualitative and quantitative damage of mulberry leaf.

The mulberry plant is propagated through vegetative method and it is grown as a perennial crop throughout the year. Like other plants and crops, larger number of insects and non-insects depend on mulberry for food and shelter. These organisms cause harm to the plant which in turn reflects on the quality of cocoon production. These organisms may also carry certain micro- organisms which are transmitted into silkworm through mulberry and leads to crop loss in terms of cocoon production.

In total, over 210 types of insects are feeding on mulberry in different parts of the globe. The degree of damage caused by these insects varies depending on the type of insects. The damage to the mulberry is during larval and adult stages of insect and such insects are called pests. Because of the polyphagous nature of pest, itcan survive even in unfavorable growth period also. Further the mulberry is periodically pruned, and the leaves are harvested for feeding of silkworm. Hence the pest attack on mulberry is less and it is seasonal when compared to other agricultural crops.

5.2. Types of mulberry pests

Generally, the mulberry pests are divided in to three groups such as the following.

1) **Sap suckers:** These are small and have short life cycle. These suckers suck the plant sap (juice) and leads to deterioration of leaf quality. During sucking of the plant sap, some of them inject toxic material into the plant which causes abnormality on the growing part (Tukra) and drying of mulberry leaf margin (Due to Jassids).

2) **Leaf eaters:** These are bigger in size and have moderate to longer life cycle. They eat away the leaf and leads to yield reduction.
3) **Root / shoot feeders:** These are smaller to larger in size and have prolonged life cycle. They feed on shoot or root of the plant which leads to drying of shoot or whole plant.

5.2.1. SAP SUCKERS

Sap feeding insects are generally very tiny and hard to detect before they begin to do damage. They get their food by piercing leaves or stems with sharp, needle-like mouth parts, and then sucking out the plant's juices. These attacks weaken plants. They tend to induce and spread plant diseases which often deform the plant, causing leaves to curl, discoloration, and speckles. The main sap sucking pests attacking mulberry are Mealy bug, Jassids, Thrips and White fly and in details literature is as follows.

5.2.1.1.1. Pink Mealy bug (Tukra Disease)

It is a major pest of mulberry and popularly known as 'hard to kill' pest. As the insects are pinkish in colour and commonly called as 'Pink mealy bug'. The scientific name is *Maconellicoccus hirsutus,* which belongs to the order Homoptera and family *Pseudococcidae.*It is a common mealy bug on mulberry and causes Tukra disease. The pest is known to infest all most all the varieties of mulberry. Its occurrence is throughout the year, but the incidence is severe during summer months. It is identified by the presence of white deposits of filamentous waxy secretion over its body as well as on the stem/branches of pest attacked plants.

It is a polyphagous pest with wide host range. There are more than 350 host plants recorded so far. The major alternative host plants are *Hibiscus*, citrus, coffee, sugarcane, guava, mango, , teak, maize, chrysanthemum, beans, cotton, soybean and many other plants. Its wide host range favours rapid spread of the pest and very difficult to manage the pest menace.

Fig.5.1. Mealy bug and affected mulberry

Symptoms and nature of damage:

1) The leaves of the infested apical shoot are wrinkled, thickened, initially become dark green in colour and then turn yellowish.
2) Heavily infested plants have shortened internodes resulting in resetting or a bunchy top appearance and the symptoms are generally called as 'tukra'.
3) Sometimes, movement of ants also observed which have symbiotic association with mealybugs.
4) The affected mulberry plants are poor in growth resulting in low leaf yield and depleted in nutritive values.

Life-cycle (24-26 days): Each adult female lay 350-500 eggs in a loose cottony terminal ovisac during a week's time. The eggs are elongated and orange in color. Depending on the climatic condition the eggs hatch in about 5-10 days. The newly hatched crawlers are orange in colour. The body is covered by white powdery secretions giving the name mealy bug. The females have three while males have four nymphal instars which are passed in about 25 and 26 days respectively. The adult reproduces parthenogenetically and they don't feed but mate and die in 2-3 days.

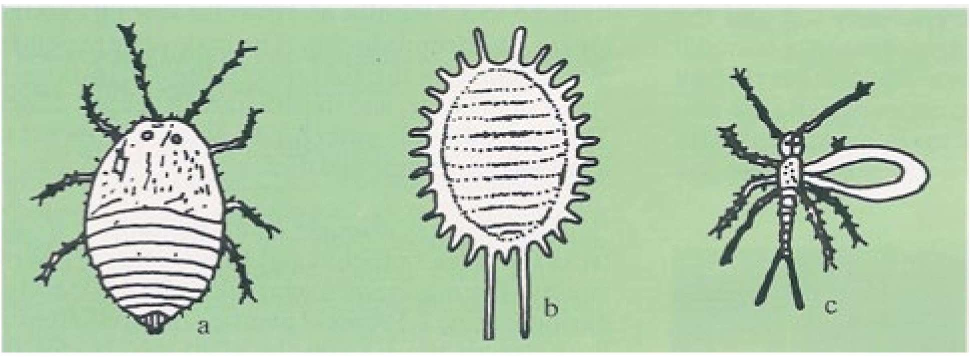


Fig. 5.2. Mealy bug Nymph, Female bug and Male bug

Control measures

1. Clip off infested portion into a polythene bag and destroy by burning or dipping in 0.5% soap solution.
2. To prevent further infestation, top clip and burn all the apical tips in the garden when the silkworms are in IV moult.
3. Do not grow alternate host plants in the vicinity of mulberry garden.
4. Spray 0.2% DDVP (2.5 ml/ litre) twice with 10 days gap after 15 to 20 days of pruning (15 days safety period).
5. As a biological control, release of predatory ladybird beetles *viz., Cryptolaemus montrouzieri* @ 250 - 300 adults/acre in two equal splits at an interval of 6 months.

5.2.1.1.2. Papaya mealybug, P*aracoccus marginatus* (Yellow Mealy bug)

Mulberry has been always preferred by several insect pests due to its nutritious leaves. During the year 2008, an exotic pest Papaya mealybug, *Paracoccus marginatus* (native of Mexico & Central America) was reported on Papaya in Tamil Nadu and reported to infest more than 60 crop plants of agriculture and horticulture importance. Now it has become a major pest of mulberry spreading fast in sericulture districts of Tamil Nadu causing severe loss to sericulture industry and has made an entry into bordering districts of Karnataka and followed by Andhra Pradesh.

How to confirm the identification of papaya mealybug: When mealybugs are pressed in between white papers, papaya mealybug gives greenish yellow stain, whereas tukra mealybug gives a pinkish stain.

Life Cycle: Each adult female mealybug lay 400-500 eggs with an incubation period of 8 to 10 days. In females, there are 3 stages (i.e., egg, nymph & adult) and in case of males, there are 5 stages of development (ie., egg, nymph, pre-pupa, pupa & adult). The first instar nymphs are called as ‘crawlers’ which are very small, active and occupy tender shoot portion or tender leaves and feed by sucking the sap. Later they settle at one place, stay there and continuously suck the sap. Adult females live for 30 to 60 days whereas males do not feed and live for very short duration. They possess a pair of transparent wings and active flyers. The females do reproduce parthenogenetically.

Symptoms: Papaya mealy bugs infest leaf buds, leaves, stem portion, stump portion after pruning etc. They are found congregating all along the veins on the underside of the leaves. Since they suck the plant sap continuously, affected leaves turn yellow and the plant growth retards. White cotton like deposits of mealy mass on the tender parts of the plant can be observed. In addition to sucking of plant sap they also inject toxic substance through their saliva, which cause deformation of plant parts. Due to heavy honey dew secretion, black sooty mould secretion is also formed. When mealy bugs infest with heavy population, the plants will end up with drying and death.

Control measure

1. The affected plants are bottom pruned and immediately it has to be burnt.
2. Spray of DDVP @ 2.5 ml / litre on the stumps immediately after pruning and the second spray after 10 days gap with Rogor @ 3 ml per liter and the third spray of DDVP @2.5 ml / 1 litre after 10 days gap.
3. Release of exotic parasitoid, *Acerophagus papayae* @ 1 vial/acre or other beetles like *Cryptolaemus montrouzieri* or *Scymnus coccivora*can also is used depending on availability.
4. Do not spray any insecticides against papaya mealybug after releasing parasitoids.

5.2.1.2. JASSIDS

These are small green insects commonly called as leaf hoppers and its scientific name is *Emposca flavescens*. These pests attack during October-May and suck plant sap from the veins on the underside of the leaf. While feeding, a virus is introduced by the hoppers into the leaf which cause 'hopper burn'. These spots are triangular brown at the tip and end of each vein indicating hopper bite. The affected leaf margin rolls up as though scorched by fire or drought. These brown margins increase in width until a narrow strip of the leaf along with the midrib remains green. The tender leaves are damaged first and coarse leaves at later stages.

It has several alternate host plants like lady’s finger, cotton, castor, brinjal, green and black gram and cucurbits.

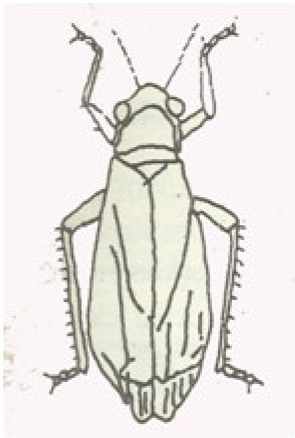


Fig. 5.3. An Adult Jassid and symptom of hopper burn

Life cycle

Adult female lays eggs which are pale yellow in color and elongated in shape, on the lower surface of the leaves below the epidermis. The eggs hatch within 4-9 days. The nymphs resemble adult but wingless are hatch out from eggs are pale green in colour. The nymph starts eating the leaf and grows slowly on the same leaf. It undergoes 4 moults and becomes adult. The adult is pale green and measures 2 - 4 mm in length, with tapering posterior end. These pests jump to reach other leaves or plants. Pupation takes place on the leaf itself.

Symptoms:

1. The pest serves as a vector for a toxic virus
2. Yellowing / drying of leaves all among the leaf margin (hopper burn) due to injection of toxic virus.
3. The leaf becomes cup shaped and wither-off prematurely.

Preventive and Control measures

a. Usage of light traps to trap adults.

b. Sprinkler irrigation disturbs the pests.

c. Spraying of DDVP at 0.05% (safe period after 3 days) or at 0.1% Rogor is effective (safe period after 10 days) to control the pest.

5.2.1.3. THRIPS

These pests cause considerable damage and there are mainly five different species of thrips causing damage to mulberry. The attack is frequent during the summer season (Feb-June) otherwise this pest is prevalent throughout the year. It is a major pest in Tamil Nadu and minor pest in Karnataka and Andhra Pradesh.

This pest is also called as thunder flies and storm flies. The common Indian species is *Pseudodendrothrips mori*. These insects affect the leaves. The epidermal tissue is injured. Early maturity, depletion of moisture, reduction in crude protein and total sugars are met-with the affected leaves. Leaves become unsuitable for healthy silkworm rearing.

Life Cycle: Adult males are brownish yellow, female is dark brown in color and larger. Female lays 30-50 bean shaped yellow colored eggs on the ventral side of the leaf. Within 6-8 days nymphs hatch, which are similar to adult except wings are pale yellow colored. The nymphs moult four times in 1-5-18 days to form adult with fringed wings.

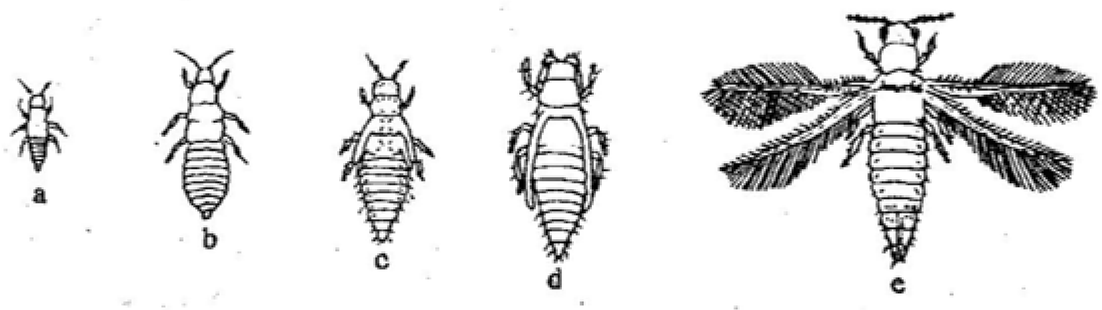


Fig. 5.4. Stages of *Pseudodendrothips mori*

a & b. Nymphs c. Pre-pupa d. Pupa e. Female adult

Symptoms:

Nymphs and adults of thrips make deep tunnels in the epidermal leaf tissues. The leaves show streaks in the early stages of attack, which become yellowish brown on maturity.

Preventive and Control measures

a. Practice of sprinkler irrigation

b. Spray of 0.2 % DDVP (2.5 ml / litre) and safety period is 17 – 20 days.

c. As a biological control method, introduction of ladybird beetles, especially *Scymnus coccivora* may be released @500 adults/acre (2 splits at an interval of 6 months) which also takes care of other soft bodies insect pests like mealybugs & white flies in addition to thrips.

5.2.1.4. WHITE FLY*(Aleurodicus disperses)*

It is a minor pest. The spiraling of waxy material is the feature from which this whitefly derives its common name, the spiraling whitefly. Its occurrence is generally during March-June and October-December. The prolonged dry spell followed by the hot humid weather favours the whitefly flares up.

It has the alternate host plants such as Guava, *Cassia auriculata*, *Abutilon*, *Annona*, banana, citrus, coconut, Indian banyan, mango, palm, papaya, pepper, plumeria and rose.

Symptoms

Majority damage is done by the first three nymphal stages by feeding. They infest the lower surface of leaves resulting in chlorosis, yellowing, upward curling of the leaves, premature leaf fall and retardation of growth. The nymphs and adults remain on the lower surface of the leaves and desap the plants. Continuous heavy feeding weakens the plant. Sooty mould development takes place and the damaged leaf become unfit for rearing silkworm.

Fig. 5.5. White fly infected mulberry leaf

Management

1. Collection and destruction of infested leaves.
2. Remove alternate wild host plants like *Abutilon* and *Cassia auriculata* and other weeds from the field and neighboring areas. iii) Reducing the activity and population buildup by fixing yellow sticky trap.
3. Spray of 0.05% Rogor (1.75 ml in 1 litre of water)

4. Spray of 0.5 % Neem oil mixed with soap solution at 1 : 2 ratio.

5.2.1.5. Scale insects

Generally, when these insects are in small numbers, the damage caused is negligible. Since these are fast breeders thus cause much damage to the plant. There are red and black Scale insects, the common Indian scale insects are *Saissetia nigra* (black scale) and *Aenidella aurantii* (red scale).The black scale insects occur on the stem and branches.

Symptoms

- When the attack is severe, the branches dry and the leaves turn yellow and finally plant dies.
- They suck the cell sap and kill the plant.
- The surface of the attacked stems is covered all over with scales. The lenticels are completely hidden thus respirative rate of the plant cells are considerably lowered.
- Yellowish or mottled appearance of the leaf blade can also be noticed.
- The red scale attacks the twigs, branches, stems. It does not attack older plant. In heavy attack the leaves become yellow finally the whole plant dries up and die.

Life Cycle: Adult female Scales lays 300-600 eggs which are minute, white, elongated. The eggs change color to reddish brown with age. The female shields the eggs which hatch in 6 days. The hatched nymphs, within few hours crawl and select the place of feeding on the stem. It secrets a fibrous waxy material that hardens forming the scale. The female moults three times while the male twice, during which appendages are lost. Thus makes the insect sedentary. They reproduce by parthenogenesis.

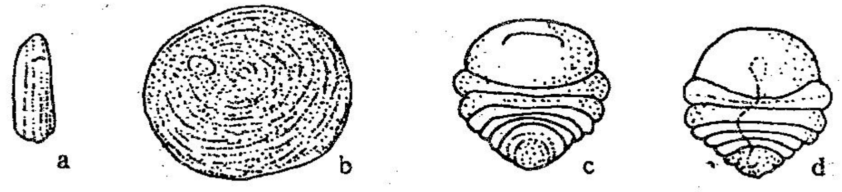


Fig. 5.6. Mulberry scale insect
a. Male scale **b**. Female scale **c**. Dorsal view of female adult **d**. Ventral view of female adult

5.7. Black and Red scale insects on Mulberry plant

3.5.2 Preventive and Control measures:

a. By cutting and burning of attacked branches.

b. Swabbing diesel oil and soap emulsion (1:3) on the stem to dislodge the scale insects.

c. Swabbing of Lime-sulphur on stem also kills and dislodges the insects.

d. Spraying 0.05 percent Malathion, safe period l0days.

e. Release of coccinellid predator – *Chilochorus kuwanae* as biological control.

f. Spreading of parasitic fungus *Attractinum indicum* is also helpful.

5.2.2. LEAF EATERS

Like the association between the silkworm, *Bombyx mori* L., and its exclusive food plant, the mulberry, the similar nature also has been visualized between mulberry and several herbivorous insect pests, including the leaf eating ones. Being mostly sporadic in nature, at times, especially during rainy (July-October) and winter (November-February) seasons of South India, the populations of the leaf eating insect pests reach epidemic proportions, leading to considerable reduction in the mulberry leaf production.

The insects, which eat the leaves or its portions on a whole are called as leaf eaters. They have longer life cycle and mainly affect the leaf yield. The main leaf eating pests are Leaf roller, Bihar hairy caterpillar, Cutworm and Wingless grasshopper

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5.2.2.1. Leaf roller (*Diaphania pulverulentalis)*

The leaf roller, *D. pulverulentalis* is a pest of mulberry in Karnataka, Andhra Pradesh and Tamil Nadu. In the subsequent years it has spread to other sericulture areas also. The infestation causes considerable reduction in leaf yield resulting in economic loss. The infestation is observed on the onset of monsoon i.e. from June and lasts up to February. However, the peak period of infestation is September-November. The infestation is observed 15 days after pruning/leaf harvest of mulberry garden. The pest is known to infest all the commercial mulberry varieties.


Fig. 5.8. Leaf roller affected mulberry and larva of leaf roller

Nature of damage and symptoms: The grown - up caterpillars are greenish brown in colour with black markings on the lateral and dorsal regions of the body segments. The leaf margins of apical leaves are rolled and tied by the larvae wherein they live. The target area of the leaf roller is the apical portion of the mulberry shoot and the young caterpillar binds the leaflets together by silky secretion and settles inside and consumes the soft green tissues of the leaf surface. The grown- up caterpillars feed on tender leaves and their faecal matter can be seen on the leaves below the affected portions.

Control measures

1. Clipping off infested portion into a polythene bag and their destroying.
2. Following of flood irrigation and deep ploughing which helps killing of the pest.
3. Spray of 0.076% DDVP (1 ml in 1 litre of water) 15 days after pruning or leaf harvest
4. Spray of 0.03% commercial neem pesticide (0.03% Azadirachtin) @ 3ml/10 litre water, mixed in 0.5% soap oil solution can be sprayed (10 days safety period).

5. As a biological control method, release of *Trichogramma chilonis,* egg parasitoids @ 1 Tricho card/acre for 4 weeks. After the release of these parasitoids, no insecticides should be sprayed to mulberry garden.

5.2.2.2. Bihar hairy caterpillar

Bihar hairy caterpillar, *Spilosoma oblique* (Lepidoptera: Arctidae) is a polyphagous pest infesting several crops including mulberry, sunflower, green gram etc. It occurs sporadically in most areas in the sericulture belt. The grown-up larvae are reddish brown in colour with black head. It measures 4 – 5.5 cm body length when mature with long and thickly grown bristles. It occurs throughout the year and however it is severe during August – February. It completes its life cycle within 45 – 50 days.

Symptoms: Dried/mesh like appearance of leaves due to feeding of young age gregarious caterpillars. The grown up larvae feed on the entire leaf rendering the branches without leaves.

Fig. 5.9. Bihar hairy caterpillar on mulberry

Control measures:

1. Collection and destroying of egg masses and gregarious young caterpillars.
2. Deep ploughing and flood irrigation to kill the pupae.
3. Spray of 0.15% DDVP to kill the caterpillars.
4. Release of *Trichogram machilonis,* egg parasitoids @ 1 Tricho card/acre / week for 4 weeks.

5.2.2.3. Cutworm

The cutworm, *Spodopteralitura* is a polyphagous pest infesting several crops such as mulberry, tobacco, castor, vegetable crops etc. It is commonly known as 'tobacco cut worm'. It occurs sporadically on mulberry where vegetable crops are commonly grown. The caterpillars cut branches and feed on leaves mostly from August to February.

Symptoms and nature of damage

The cutworm larva is stout, cylindrical and pale greenish brown in colour with dark markings. It has transverse and longitudinal gray and yellow bands on the body. The cutworm caterpillars attack shoots of young mulberry plants and cut them, hence the name cutworm. The cut portion of the shoot dries up and falls off.

Control measures

1. Collection and destroying of egg masses and young caterpillars.
2. Using of light traps to attract moths by placing a tray with 0.5% soap solution below the light source and kill them.
3. Spray of 0.15 % DDVP (2 ml DDVP in 1 litre of water).

5.2.2.4. Wingless grasshopper

It is scientifically called *Neorthacris acuticeps nilgirensis*, its nymphs and adults voraciously feed and reduce leaf yield considerably. Besides causing extensive damage to mulberry this pest infests sunflower, ragi, groundnut, beans, potato, jowar, etc. This pest occurs during June to September.

Symptoms and nature of damage: Presence of irregular size holes on the leaf as the pest feeds from middle of the leaf and the plants remains without leaves when the attack is severe.

Life cycle: Adult wingless grass hopper is green in color. Female adult lays 6-8 egg pod each having 11-18 eggs. These egg pods are deposited in the loose soil at a depth of 2-3cm which hatch in 28-31 days. The nymph passes six moults to become adult. The early nymphs are light brown while late instars are green in color. It completes the life cycle in 5-6 months.

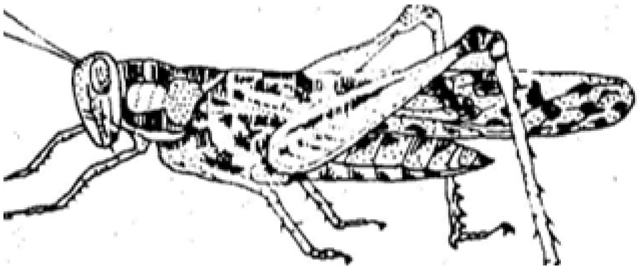

Fig. 5.10. Wingless grasshopper (Adult)

Preventive and Control measures:

1. Exposure of egg masses to sun light by deep ploughing.
2. Removal of weeds in the garden and surroundings to minimize the multiplication of pests.
3. Collection and destruction of nymphs and adults.
4. Spray of 0.076 % DDVP (1 ml of DDVP in litre of water) on mulberry foliage to kill nymphs and adults. If infestation is severe, a second application is also recommended with a gap of 10 days.

5.2.3. ROOT / SHOOT FEEDERS

These types of pests have prolonged life cycle and vary in size. They feed on roots / shoots of the mulberry plant leading to drying up of the plants. The major root / shoot feeding pests attacking on mulberry are Stem borer, May-June beetle and Termites.

5.2.3.1. The stem borer, Apriona spp.

The adults are large, elongate, dark gray coloured insects with long antennae. It occurs throughout the year.

Symptoms of attack and extent of damage:

The pest attack indicates the holes on stem / branches which leads to the gallaries / tunnels made by the boring larvae. The attacked branches are initially withered followed by drying is observed.

Fig. 5.11. An adult of stem borer

Control measures

1) Cutting and burning of heavily attacked branches.
2) Killing of the grubs using a flexible wire inserted into tunnels.
3) Swabbing the base of the main stem or branches with 0.1 % Malathion (50 % EC) emulsion or 0.08 % Chloropyriphos (20% EC).
4) Injection of 0.1 % Chlordane into the holes to kill the boring larvae.

5.2.3.2. May - June beetle

It is also called 'cokchafer beetle' and it occurs mostly during May – June months. It is also called as white grub, due to the body colour of the grub (larva) which lives underground where it damages the roots.

Symptoms of attack and extent of damage

1) Branches without leaves at different places.
2) Drying up of the plants due to damage to roots and rootlets.

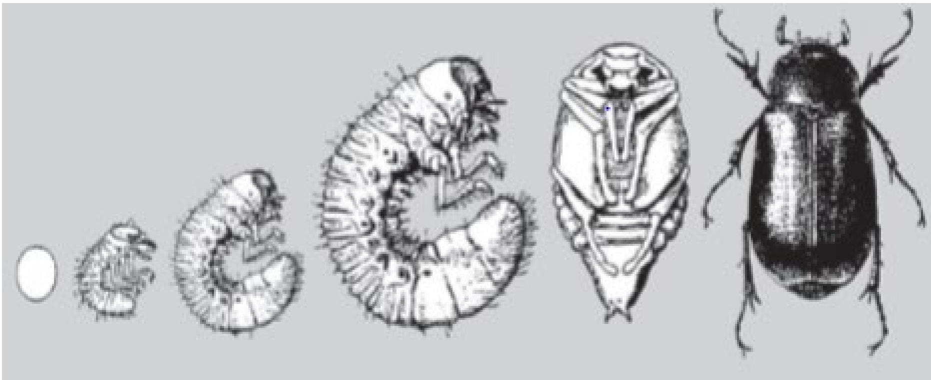

Fig. 5.12. Stages of cockchafer beetle (Life cycle)

Control measures

1) Tying up of a few fresh neem branches to mulberry plants in different parts of the garden to attract the adults followed by their collection and destruction.
2) Installation of light trap and collection of adult beetles during night in kerosene mixed water.
3) Soil application of 0.2 % Malathion or Chloropyriphos dust.
4) Foliar application of 0.15 % (2 ml / one litre of water) DDVP or 0.2 % Neem oil (2ml / litre of water) and safe period is 10 – 12 days.

5.2.3.3. The termites

The termites appear throughout the year. It damages the nurseries, stem and roots of mulberry. It's attack in the ground on main root results in breakdown the system of food supply of the plants and thereby results in reduction in leaf yield, production of inferior leaf quality and the death of plants. In some plants leaves get early maturity and turn into yellowish color. After attack, the healthy mulberry plants die within two years, some become nonproductive and perish slowly. The pest is not found in association with any disease and the attack is observed primary in the nature. Termites do not have any specific choice for a mulberry variety and it prefers mulberry plants as compare to other trees.

Its presence can be observed through formation of earthen sheath on the stem and the presence of subterranean galleries.

Symptoms and extent of damage

1) The termites construct earthen sheath on the stem and feed on the bark.
2) They make subterranean galleries and feed on the roots.
3) Small to bigger earthen mounds above and below the soil.

Control measures

1) Removal and destruction of mounds and queen from the colony.
2) Treatment of mounds with Chloropyriphos (20 % EC) @ 45 ml dissolved in 15 litres of water per mound.
3) Swabbing or drenching of the base of the established plants with 0.08% Chloropyriphos and the safe period is 12 days.
4) Treatment of the mulberry seed cuttings with 0.1% Chloropyriphos before planting.

5.3. Reasons for pest outbreak in mulberry

The following are the major reasons for outbreak of pests during mulberry cultivation.

1. Availability of succulent leaf throughout the year.
2. Cultivation of mulberry in large areas.
3. Favourable climatic conditions for multiplication of pests.
4. Increased use of nitrogenous fertilizers.
5. Reduced activity of natural enemies like predators, parasitoids and pathogens.

6. Absence of other competing pests and presence of alternate host plants in the vicinity of mulberry garden.
7. Indiscriminate use of chemical pesticides leading to pesticide resistance and secondary pest outbreak.

5.4. Preparation of insecticides

The active toxicant in a commercial formulation suitable for direct application is rarely available because small quantity of active ingredient has to be distributed on a large area. Dilution, therefore, becomes another important aspect for consideration. To obtain the weight or volume of solid or liquid formulation of commercial insecticide available in market for the preparation of a solid or liquid containing a desired percentage of toxicant,the following formula can be applied.

$$d = \frac{a \times b}{c}$$

Where

a = % of toxicant desired or recommended

b = Weight of dust or volume of liquid required

c = % of toxicant available in the commercial insecticide formulation.

d = Weight in grams / kgs volume of commercial formulation required.

B = After obtaining the value of d, the following calculation should be carried out to obtain the weight or volume of diluent (e).

Volume of diluent (e) = Value of (b) – value of (d)

Example 1. To prepare 200 litres of spray solution of 0.076 % Dichlorovosfrom 76 % EC of the pesticide, how much quantity of commercial pesticide is to be purchased.

$$\text{Calculation } (d) = \frac{0.076 \times 200}{76} = 0.2 \text{ litres}$$

Hence, to prepare 200 litres of solution with 0.076 % concentration, 0.2 litres of pesticide have to be mixed with 199.8 litres of water.

Example 2. Prepare 200 litres of 0.2% dimethoate, from the commercial formulation dimethoate with 30 % EC.

a = 0.2 % dimethoate
b = 200 litres
c = 30 % EC
d = ?

$$= \frac{0.2 \times 200}{30} = 1.33 \text{ litres}$$

To prepare 200 litres solution, 1.33 litres of commercial pesticide to be mixed with (200 litres – 1.330 litres) 198.67 litres of water.

5.5. Integrated pest Management (IPM): Integrated pest management or IPM, is a process used to solve pest problems while minimizing risks to people and the environment. IPM can be used to manage all kinds of pests anywhere–in urban, agricultural and wildland or natural areas. IPM is not a single pest control method but, rather, a series of pest management evaluations, decisions and controls.

IPM is an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties. Pesticides are used only after monitoring indicates they are needed according to established guidelines, and treatments are made with the goal of removing only the target organism. Pest control materials are selected and applied in a manner that minimizes risks to human health, beneficial and nontarget organisms and the environment.

How does IPM works?

IPM focuses on long-term prevention of pests or their damage by managing the ecosystem. With IPM, taking of actions to keep pests from becoming a problem. Rather than simply eliminating the pests using IPM means taking care of environmental factors that affect the pest and its ability to thrive.

Monitoring and correct pest identification under IPM: Monitoring means checking fieldto identify which pests are present, how many there are, or what damage they are causing. Correctly identifying the pest is key to knowing whether a pest is likely to become a problem and determining the best management strategy.After monitoring and considering information about the pest, its biology, and environmental factors, it could be decided whether the pest can be tolerated or whether it is a problem that warrants control. If control measures are needed, it helps to select the most effective management methods and the best time to use them.

Combine approaches through IPM strategies for greater effectiveness: The most effective, long-term way to manage pests is by using a combination of methods that work better together than separately. Approaches for managing pests are grouped in the following categories.

i. **Biological control:** It is the use of natural enemies such as predators, parasites, pathogens, and competitorsto control pests and their damage. Invertebrates, plant pathogens, nematodes, weeds and vertebrates have many natural enemiescan be identified and used as a biological control method.
ii. **Cultural controls:** These are the practices that reduce pest establishment, reproduction, dispersal, and survival. For example, changing irrigation practices can reduce pest problems, since too much water can increase root disease and weeds.
iii. **Mechanical and physical controls:** Under this method, killing a pest directly, block pests out, or make the environment unsuitable for it. Traps for rodents are examples of mechanical control. Physical controls include mulches for weed management, steam sterilization of the soil for disease management, or barriers such as screens to keep birds or insects out.
iv. **Chemical control:** It is nothing but the usage of pesticides. Under IPM, pesticides are used only when needed and in combination with other approaches for more effective, long-term control. Pesticides are selected and applied in a way that minimizes their possible harm to people, nontarget organisms, and the environment. The most selective pesticide needs to be used to eradicate the pest menace.

As per the situation of pest incidence, the following major components are used to control pest attack through IPM programs which are as follows.

a. Pest identification.

b. Monitoring and assessing pest numbers and damage.

c. Guidelines for when management action is needed.

d. Preventing pest problems.

e. Using a combination of biological, cultural, physical/mechanical and chemical management tools.

f. After control measures are taken, assessing the effect of pest management.

IPM in Sericulture: The success of sericulture industry in India is mainly attributed to the well-planned annual sericultural activity and the systematic implementation of pest preventive and control measures. The insect spectrum of silkworm and its food plants is complex and plays a major role in limiting the production of silk. About 200 insect and non-insect pest species attack mulberry due to indiscriminate use of chemicals and fertilizers. Among these, Pink mealy bug (*Maconellicoccus hirsutus*), papaya mealy bug (*Paracoccus marginatus*), leaf webber (*Diaphania pulverulentalis*) and thrips (*Pseudodendro thrips mori*) are the major pests.

In recent times, it is proved that an integrated approach involving both chemical and biological methods was more effective than individual methods for the control of pests and diseases as well as for the nutrient management in agriculture crops. However, indiscriminate usage of chemical fertilizers and pesticides is the main culprit responsible for agriculture pollution leading to the chemical and pesticide residues in almost every agricultural consumable and the soil fertility is getting gradually deteriorated.

Insects cause extensive damage to plant whereas predators and parasites either kill the silkworm larvae or force them to spin flimsy cocoons. Unilateral control measure against this pest is mainly based on the use of synthetic organic insecticides. Though these approaches initially paid rich dividends, the undesirable consequences soon surfaced. Insecticide induced resurgence of gall midges, leafhopper, leaf roller, secondary pest out breaks and development of pest biotypes has led to realization of Integrated Pest Management in sericulture. Various components of IPM, viz. Host plant resistance, cultural practices, biological control, chemical control and integrating them for their control is necessary. Sources of host plant resistance have been identified for some of the major insect pests. Cultural practices like pruning, pollarding, judicious use of nitrogen, optimum spacing and weed management have prayed to be the powerful tools in controling pests. Natural control over the pest population build- up exerted by the wide range of parasitoids, predators and pathogens has been well documented with identification of natural enemies and studies on their potential.

It is the need of the hour that instead of depending exclusively on chemicals and pesticides it is more economical and can be ensured healthy impact on the environment and soil health in the long run. Several biological methods are available for the control of diseases and pests in mulberry and silkworm which can reduce the use of pesticides and chemicals. Natural enemies of pests, bio-pesticides and bio-manures are very effective when used in an integrated manner.

Neem Oil emulsion: 0.3% neem oil dispersed in 0.05 % soap solution (Dissolve 50 grams of soap powder in 100 litres of water then mix with 300 ml of neem oil). Spraying of this emulsion to the mulberry garden for three times *i.e.* First spray after 10 days and 2nd spray after 20 days and third spray after 30 days after pruning found to be more effective in controlling all the sucking insects.

Likewise, all the pest incidences that occurring during mulberry cultivation, control measures are explained pest wise separately. However, wherever and whenever possible, alternate biological methods may be followed to avoid or to reduce the application of pesticides and chemicals without hampering the productivity.

Summary

Large number of insects and non-insects depend on mulberry for food and shelter which cause damage reflecting on the low quality and quantity of cocoon production.The mulberry, the only food plant of the silkworm, Bombyx mori L. is attacked by several pests causing qualitative and quantitative damage. The attack by the pest causes leaf yield reduction in addition to affecting the quality. Majority of the pests occurs throughout the year and have short life cycles completing several generations in a year and multiplying at a faster rate. The important pests include Mealy bug, Leaf roller, Bihar hairy caterpillar, wingless grasshopper, scale insects, jassids, thrips, cutworm, spiraling white fly, stem borer, termites, etc. Various factors responsible for pest outbreak have been identified for effective management. The preparation involved in the preparation of various pesticides also has been

discussed. Further, the importance of Integrated Pest Management (IPM) has been discussed with reference to sericulture industry.

QUESTIONS

I. Short Questions

1. Define pest?
2. What is the hopper burn?
3. What is tukra disease?
4. What is the causative organism of hopper burn?
5. What damage is caused by stem girdler?
6. Name some mulberry pests.
7. What is the causative organism of shoot holes?
8. How do you control scale insects?
9. What is the damage caused by Bihar hairy caterpillar?
10. What is the damage caused by termites?
11. How do you control thrips?
12. What is the causative organism of tukra?
13. How do you control stem girdler?
14. What is IPM?
15. How to differentiate between Pink mealy bug and Yellow mealy bug?

II. Essay Questions

1. Describe in detail about Bihar hairy caterpillar and preventive and control measures
2. Write about life cycle of scale insects.
3. Jassids are serious pests - comment.
4. Describe about thrips.
5. Describe about mealy bug.
6. Write short notes on

a) Termites b) Grass hopper c) Tukra

7. Write short notes on

a) Powder pest beetle b) Jassids c) Mealy bugs

8. Write in detail about IPM strategies for sericulture?

9. Write in detail about the procedure involved in the preparation of pesticides?

10. Write in details about the mealy bugs?

Ψ

UNIT 6

Estimation of Leaf Yield

Structure

6.1. Introduction

6.2. General norms for a satisfactory mulberry garden (irrigated conditions)

6.3. Method of mulberry leaf estimation

Summary

Learning Objectives

After studying this chapter students should be able to

- Know the importance of mulberry in the success of silkworm rearing
- Know the general norms for a satisfactory mulberry garden
- Understand the steps involved in leaf estimation
- Estimation of leaf in different plots of various spacing systems.
- Study the importance of leaf estimation.

6.1 Introduction

Mulberry being practically the sole food of the silkworms and it is obvious that the quality of mulberry leaf has a predominant influence on the development of the silkworms and the quality of cocoon. Mulberry is exploited mainly for commercial production of silk and nearly 60 % of the cost of cocoon production accounts for mulberry leaf production. The quality of mulberry leaf alone contributes to the tune of 38.2 % for the success of the silkworm crops. Therefore, the production of good quality mulberry leaf with reduced cost is a pre-requisite for the sustained growth of sericulture industry.

Mulberry falls under the plants of perennial crops and once it is properly raised during the first year, it can attain to its optimum yielding capacity during the second year and lasts for about 15 years without any significant deterioration of leaf yield. The optimum leaf yield could be ensured by following recommended package of practices for mulberry cultivation. The yield potential of high yielding varieties can be best realized in high fertility soils and they respond to intensive irrigation.

Due to intervention of technologies and R & D efforts, mulberry productivity has improved to the extent of 25 – 30 MT / ha / year as against a low yield of about 10 – 15 MT / ha / year in farmer's traditional system of cultivation. The technology included the growing of mulberry varieties, Kanva-2 (M5) in place of poor yielding local mulberry variety. Later, addition of high yielding varieties like S-30, S-36 and S-54 have increased the leaf yield to the tune of 40 – 45 MT / ha /year. Later after the introduction of another new variety like V-1 (Victory – 1) the leaf yield potential has gone up to 65 – 70 MT / ha / year. This variety has proven excellent under efficient farming system with high fertilizer input. Very recently another new mulberry variety, G4 is introduced with high yielding capacity under irrigated conditions and it has high growth and branching capacity. Under assured irrigated conditions, leaf yield could be ensured on par with V-1 variety.

The quality of mulberry leaf is the backbone of successful silkworm rearing and it could be considered on priority basis for proper planning of silkworm rearing schedule. The quantity of brushing is determined by annual harvesting of mulberry leaves depending on the area of mulberry garden, labour force, rearing room and rearing implements. The quantity of mulberry leaves required to rear the larvae differs in the spring and autumn rearing and it also varies according to the choice of the hybrids procured. In spring the quantity of mulberry leaves required for rearing are less compared to summer-autumn rearing. Besides adjusting the quantity of mulberry leaves supplied according to the conditions prevailing outside, the quantity is also changed depending upon the quality of mulberry leaves. For example, if the mulberry leaves are immature and tender, their quantity per feed is decreased to some extent, and if matured, the number of feeds as well as the quantity per feed increases. If the nutrient contents of the mulberry leaves are less and hampers the growth of the silkworm, the suitability or unsuitability of mulberry leaves fed to silkworm larvae greatly affects the rearing. The quantity and quality of mulberry leaf supplied for silkworm rearing are important aspects to harvest good cocoon crops.

The quality of mulberry leaf supports good growth and development of silkworm larvae. Good quality leaves are obtained from mulberry garden grown by adopting optimum agronomic practices like application of manures and fertilizers, timely irrigation, inter cultivation, plant protection measures etc. The commencement of rearing should be according to the stage of the garden so that bulk of the harvest is made and utilized at the correct stage of leaf maturity. Further it also ensures higher leaf yield. Insufficient quantity of feed does not permit full growth of silkworm larvae and survival ability which are very important from the point of view of overall cocoon yield and returns. On the other hand, over feeding leads to accumulation of rearing bed and wastage of mulberry leaf and such condition is harmful to the silkworms. Good silkworm rearing emphasizes proper regulation of quantity of leaf to suit different larval instars and the right quantity of feeding. The assessment of these two parameters *i.e.* quality and quantity are of prime importance in sericulture.

In general, mulberry leaf yield per acre per year range from 12,000 - 14,000 kg in M_5 variety and it is 20,000 - 25,000 kg. in irrigated garden with V 1 variety. The yield estimates in sericulture are as follows.

- Approximately one laying (One Dfl) contains 450 - 500 eggs and needs 12 - 15 kg mulberry leaves for its rearing. On an Average 70 - 80 kg of cocoon yield can be obtained/ 100 DFLs.
- Production of 1 kg of cocoon needs an approximate quantity of 18 - 20 kg of mulberry leaves but it is dependent on variety, quality of mulberry leaves and season of rearing.
- For rearing of 100 Dfls, rearing bed space of 700 - 750 sq.ft. for cross breeds and 800 sq.ft. for bivoltine silkworm hybrids is required. This depends on Silkworm breed and silkworm rearing management.
- For systematic planning of silkworm rearing and to meet day to day requirements it should be necessary to assess the leaf production which will help in estimation of silkworm rearing capacity.

6.2. General norms for a satisfactory mulberry garden (irrigated conditions)

- At least 1000 Dfls rearing capacity / acre / year with a cocoon production of at least 500 kgs.
- In a good and well-maintained mulberry garden about 1500 Dfls can be brushed / acre and 900 kgs of cocoons can be produced in every year.
- The age of mulberry garden suitable for final age is 60 – 65 days and therefore brushing between 40 – 45 days after pruning is ideal.

In general the Leaf : Shoot ratio is as follows

- It is mainly dependent on the age and variety of the mulberry garden.
- In Tender garden (35 – 45 days garden) – 65 % leaf : 35 % shoot
- In matured garden (60 – 70 days garden) – 52 % leaf : 48 % shoot

- In shoot lets - 75 % leaf : 25 % shoot
- The leaf and shoot ratios may vary with the soil fertility, irrigation conditions and application of manures and fertilizers. Further it also depends on the intercultural operations and other package of practices followed.
- The leaf : Cocoon ratio requirement is 1500 – 1800 kg leaf consumption and 55 – 65 kg of cocoon production. Then the leaf: cocoon ratio will range from 1 : 25 to 1. : 28.

6.3. Method of mulberry leaf estimation

Accurate and early estimation of leaf yield is an important skill and the farmers require accurate yield estimate to take the decision for the procurement of Dfls or Chawki silkworms. Extensive personal experience is essential for estimating yield at early stages of growth. As crops near maturity, it becomes easier to estimate yield with greater accuracy.

So, the estimation of mulberry leaf is essential before brushing of silkworm eggs. One cannot assume the number of DFL's to be brushed basing on simple observation of field. Once the leaf is estimated it would be easy for the farmer to calculate the number of layings required. If rearing is planned without leaf estimation, sometimes it becomes a problem in late age rearing leading to scarcity of leaf or leaf will be remained unused in the garden. It is advised to estimate the leaf 10-12 days prior to brushing of silkworm eggs.

It is a prerequisite to specify plot size for assessment of mulberry leaf yield. The cultivation system and crop pattern for that system is to be known. The assessment is to be done for every crop in a year. The sampling for leaf yield estimation is done according to standard principles which are in practice. To calculate the mulberry leaf estimation the following steps, need to be considered.

1. Expected number of plants in the mulberry plot (Number)
2. Plant density in selected plot (%)
3. Assessment of actual number of plants in a plot (Number)
4. Average leaf yield per plant (kgs)
5. Expected increase in leaf yield (%)

Uniform production of leaf yield throughout the year is difficult to achieve as leaf production varies depending upon the season and management practices. Hence, before taking up silkworm rearing, it is very much important and essential to assess the availability of leaf to decide the quantum of silkworm layings to be brushed. However, the individual step as mentioned above are calculated as below

I. Expected number of plants in the mulberry plot

This is to know the expected plant number in title plot.

a. Expected no. of plants in the plot

= Standard number of plants per acre X plot size

b. Standard number of plants/acre

One acre of land is equivalent to 43560 sq.ft or else it is equal to 100 cents

$$\text{Expected number} = \frac{43560 \text{ sq.ft}}{\text{Plant spacing (ft.)}}$$

Example: in one acre of mulberry garden with $2'x2'$ system how many plants can be accommodated

$$\text{Expected number} = \frac{43560 \text{ sq.ft}}{2` \text{ x } 2` \text{ (ft)}}$$

$$= \frac{43560}{4` \text{ Sq. ft}} = 10890$$

It means 10890 plants can be expected or accommodated in one acre

When the planting area is 0.8 acre

Then no. of plants in a plot = 10890 x 0.8=8712 plants

The expected plants are 8712.

II. Plant density in selected plot

Observe fail pit percentage, based on actual count of plants in an expected 200 plants/ unit area.

$$\% \text{ effective plant density} = \frac{\text{Actual number of plants in 200 plants area}}{200} \times 100$$

If the number is 150 instead of 200 then the plant density is

$$= \frac{150}{200} \times 100 = 75\ \%$$

III. Actual number of Plants in the plot

It is estimated when the plot area is 0.8 acre.

$$= \frac{\text{Expected number of plants x Density (\%)}}{100}$$

$$= \frac{8712 \times 75}{100} = 6534 \text{ plants}$$

IV. Leaf yield/plant

This is estimated depending on the system of cultivation. In shoot system harvest, the leaf yield is assessed based on yield of randomly selected three plants. These three plants are pruned, and leaves are separated.

Then leaf yield is estimated as

$$\text{Leaf yield per plant} = \frac{\text{weight of leaf alone(Kg)}}{\text{no.of plants harvested}}$$

When the total leaf weight from three plants is 0.390 kg

$$\text{The single plant leaf production} = \frac{0.390}{3} = 0.130 \text{ kg}$$

Therefore, the estimated leaf yield for the entire plot is calculated using actual number of plants and leaf yield per plant which is as follows.

Leaf yield in entire plot = actual No. of plants x leaf yield/plant

= 6534x0.130kg = 849.42kg

= 850 kg leaf

In leaf harvest system the leaf yield per plant is estimated as leaf harvest from three plants as detailed above.

V. Expected increase in leaf yield

Generally, the leaf yield increases than expected by the time the field is utilized for silkworm rearing. Assessment of leaves during brushing period is done nearly before 10-12 days and from brushing to peak utilization it is done nearly for 20 days. Therefore, nearly 30 days expected growth and increase in leaf yield should be considered in estimating the leaf yield at the peak period. If the leaf yield assessment is done at 30 – 35 days after pruning, it is expected to double in another equal period. The peak leaf yield is therefore assessed by doubling the estimated leaf yield on the 30th or 35th day of pruning. The peak leaf yield is therefore assessed by doubling the estimated leaf yield on the 30th or 35th day of growth.

Leaf yield x Actual Number of plants x 2

= 0. 130 x 6534 x 2 = 1700kg leaf per 0.8 acre

Then it is said to be 1700 kg of mulberry leaf is expected in peak growth period out of 0.80 acre of mulberry garden.

6.3.1 Model problem-I

A farmer cultivated 1.2 acre of mulberry and 3'x3' spacing is adopted. The actual number of plants is only 130 in an area of 200 plants. What would be the leaf yield? if the leaf weight of three plants is 0.400kg.

$$= \frac{\text{standard number of plants per acre}}{\text{plant spacing}}$$

$$= \frac{43560 \text{ sq.ft.}}{3` \times 3`} = 4840 \text{ plants}$$

Farmer's plot area is 1.2 acre

Then, the number of plants in total 1.2 acre of garden =4840 x 1.2=5808 plants

In 1.2 acre area of land, 5808 plants are expected

Actual count of plants in expected 200 plants unit area for which actual plant density percentage needs to be calculated.

$$= \frac{\text{Actual number of plants x 100}}{\text{200 plants area (Expected number)}}$$

$$= \frac{130 \times 100}{200} = 65\% \text{ plant density percentage}$$

Actual number of plants in 1.2 acre area is therefore

$$= \frac{\text{Expected number of plants x plant density}}{100}$$

$$= \frac{5808 \times 65}{100}$$

$$\text{Leaf yield per plant} = \frac{\text{weight of leaf(kg)}}{\text{no.of plants harvested}}$$

$$= \frac{0.400}{3} = 0.133 \text{ kg}$$

Leaf yield per entire plot = actual number of plants x leaf yield

= 3775x0.133 = 502.07 kg.

Expected increase of leaf yield = leaf yield x actual number of plants x 2

= 0.133 x 3775 x 2 = 1004.15 kgs leaf

Hence, per 1.2acre area of mulberry garden belonging to the farmer can be expected to harvest 1004 kgs of leaf. Accordingly, he needs to plan for bringing of silkworm eggs or chawki silkworms from chawki rearing centers.

PRACTICAL

1. Estimate the actual plant density in a given mulberry plot.
2. Calculate the expected number of plants in various plant spacing systems
3. Estimate the mulberry leaf in a given mulberry plot.

SUMMARY

❖ *Uniform production of mulberry leaf yield throughout the year is difficult to achieve as leaf production varies depending upon the season and management practices. Hence, before taking up silkworm rearing, it is very much important and essential to assess the availability of leaf to decide the quantum of silkworm layings to be brushed.*

❖ *The quality and quantity of mulberry leaf is essential in sericulture. The suitability or unsuitability of mulberry leaves fed to silkworm larvae greatly affects the rearing. The quality of leaf supports growth and development of silkworm larvae and finally has a greater impact on quality and quantity of cocoons produced.*

❖ *The Leaf estimation is necessary before brushing of silkworm eggs. Rearing without leaf estimation causes lot of problems during rearing which may lead to shortage or excess of leaf and such incidences are economic loss to the farmer."*

❖ *Leaf is to be estimated 10-12 days prior to silkworm brushing. The plot area, plant spacing, actual number of plants based on count and leaf yield per plant are essential to calculate the leaf yield in a given area. Basing on the mulberry leaf yield, the number of Dfls to be brushed are estimated for silkworm rearing.*

QUESTIONS

I. Short Questions

1. When do you estimate the mulberry leaf?
2. Why the leaf estimation is necessary in sericulture?
3. How the leaf yield/plant is calculated?
4. What are the steps involved in leaf estimation?
5. What is the approximate leaf : cocoon ratio?

II. Essay Questions

1. Write in detail procedure for estimation of mulberry leaf?
2. Write about the importance of mulberry in silkworm rearing and leaf estimation procedure in a nut shell manner?
3. Estimate the leaf yield on the following details
   The mulberry plot size 0.6 acres with a spacing of2'x3' and actual plants are 135 out of 200 plants unit area and the weight of leaf per 3 plants is 0.410kg.
4. Estimate leaf yield of the plot size having 1 acre and planted with a spacing of 2'x2' and the actual plants density are 165 in a unit area of 200 plants. The Weight of leaf in 3 plants is 0.450kg.
5. Estimate leaf yield for mulberry plot size having 1.25 acres with a spacing of 1.6'x1.6' and the actual plants are 150 in a unit area of 200 plants. The weight of the leaf in 3 plants 0.575kg.

Ψ

UNIT 7

Establishment and maintenance of chawki garden

Structure

Learning Objectives

After studying this chapter students will be able to

- Study the establishment of chawki mulberry garden
- Understand the importance of chawki mulberry garden
- Know the package of practices to be followed for ensuring quality mulberry leaf for chawki silkworms

7.1. Introduction

The silkworm (*Bombyx mori* L.) is a monophagous and highly domesticated insect. The qualitative and quantitative requirements of the feed for silkworms differ at different stages of the larval period. It is generally established that the young age silkworms require mulberry leaf of higher succulence, moisture and nutrient contents, the late age worms feed on coarser leaf with less moisture content. By providing this type of quality leaf, the young silkworms will be healthy, develop resistance to diseases and produce good quality cocoons. The quality of leaf used for young worms is of greater relevance in view of the influence of chawki rearing on the late age silkworms and ultimately the success of cocoon crop. If the coarse leaf is provided to the young silkworms, they become weak and prone to various diseases in later age due to lower moisture content and poor quality of leaf. In such circumstances, production of succulent and nutritious leaf attains greater significance for chawki silkworms. On the other hand, growth of chawki mulberry plants should be monitored in such a way so as to reduce the coarseness and rate of maturation of mulberry leaf thereby avoiding wastage of the biomass produced from such mulberry gardens.

Importance of Chawki mulberry garden: The main purpose is to develop a separate mulberry garden as a continuous source of production of quality leaf suitable to chawki silkworm rearing. Among all the factors responsible for healthy/successful chawki rearing, leaf quality plays an important role. Moreover, the nutritional requirement of chawki worms is totally different from that of the late age worms. One of the vital factors contributing to successful young age silkworm rearing is the supply of highly nutritious mulberry leaf. The leaves fed to chawki larvae should be tender, soft, succulent and rich in protein (25%), carbohydrate (14%) with minimum moisture of 80%. The availability of such specific and suitable quality leaf in general mulberry gardens is not adequate, as these leaves contain less moisture (less than 70%) and poor in terms of required nutritional constituents. Thus, a separate mulberry garden for quality leaf production for young age silkworm rearing (Chawki) is imperative. Further, hygienic and proper chawki rearing with good quality leaf will increase disease tolerance in silkworm and help them remain healthy till spinning of cocoon. Keeping in view of the importance, separate chawki mulberry garden needs to be maintained with suitable package of practices. Moreover, having a separate mulberry garden exclusively for chawki Rearing Centers (CRC) would be ideal to produce quality and healthy silkworms.

Establishment and Management of Chawki garden

Exclusive chawki mulberry gardens can be raised in flat and elevated places with red loam, red sandy loam and red clay loam, with a pH range of 6.5-7.5. The land must be free from nematode, termite infestations and should have assured source of irrigation. Establishment of plantations is ideally taken up during the rainy season (June-September) for better establishment of mulberry garden. Before the onset of monsoon, land has to be ploughed to a depth of 30 – 35 cm using a tractor. The land is then leveled. The mulberry varieties like S36, V1 and G2 are more suitable for establishment of chawki mulberry garden under irrigated conditions. Mulberry plantation gets established generally in 8 – 10 months' time. During the establishment period of the plantation, proper care must be taken to support the plants to grow properly. Irrigation should be provided at regular interval of 7 – 10 days depending on the soil condition. Weeding should be done manually after two months of plantation. When the plantation is 3 months of old, application of chemical fertilizers at the rate of 50 kg nitrogen, 50 kg of phosphorus and 50 kg of potash per hectare as the first dose and the plants should be allowed to grow for about 6 months without pruning or leaf harvest.

The second weeding should be done after four months of plantation and another dose of nitrogen at the rate of 50 kgs per hectare is to be applied. When the plants are 6 – 8 months old, it is suitable for first pruning. The plants should be pruned with the help of secateurs at the height of 20 – 25 cm above the ground level to build a well-developed crown. Only 10 – 12 shoots should be allowed to grow from each plant and all excess side branches including weak branches are to be removed. With the above procedure the chawki garden has to be established and 2nd year onwards the chawki garden needs to be maintained with recommended package of practices.

Package of practices for the maintenance of chawki mulberry garden from the second year onwards involves pruning, ploughing of the land, weeding, application of manures and chemical fertilizers in time, irrigation at regular intervals as well as harvest of 8 crops per year as leaf and shoot lets. In order to harvest quality of leaf recommended package of practices without any deviation are to be followed.

Plantation: The ideal spacing to be adopted is 90 x 90 cm or paired row system with a spacing of [(90+150) x 60 cm]. Further, any existing garden with a spacing of 60 x 60 cm can also be converted into a chawki plot. Under irrigated conditions, mulberry is planted either in pit with a spacing of 90 x 90 cm or row system of dense plantation following row to row spacing of 60 cm and plant to plant spacing of 20 cm.

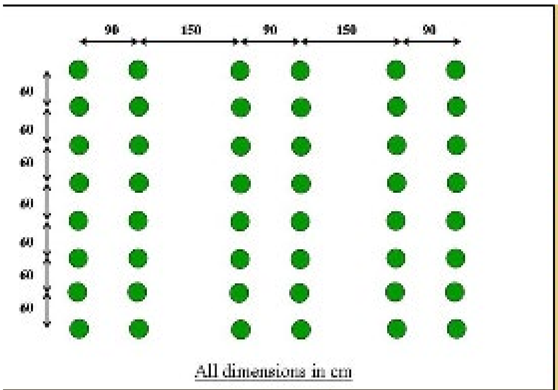

Fig.7.1. Paired row system of plantation

Application of manures and fertilizers: Once the mulberry garden is established, it can give yield of mulberry leaf consistently for more 10 – 15 years. This could be ensured when the garden is maintained with proper inter-cultivation and soil fertility. It means the capacity of the soil to supply essential nutrients for good growth of the plants. The nutrient demand in case of mulberry is high due to intensive cultivation, harvesting and periodical repeated pruning. Therefore, it is very essential to replenish the deficient nutrients. To know the exact requirements of the nutrients, periodically soil needs to be tested for both macro and micro nutrients.

Manuring plays an important role in building up soil fertility and increasing moisture holding capacity and growth of micro-organism in the soil. It also improves micro-nutrients levels and the physical conditions of the soil. Further it also increases the soil moisture retention in sandy soils and easy percolation of water in clay soils. Hence, application of adequate quantity of organic manure to maintain the fertility status of the soil is very essential. Well decomposed farmyard manure is to be applied at the rate of 40 MT / ha / year in two equal splits of 20 MT each in 1st and 5th crops and it can also be applied as 5 MT / ha after each harvest.

Fertilizers are applied at the rate of 225: 150 : 150 NPK kg / ha / year or in eight equal splits of 28 : 19 : 19 NPK kg / ha / crop. This is applied as 127 kg Suphala (15N : 15P : 15K) plus 20kgs of urea is applied per crop. For alkaline soils NPK is applied in the form of 136 kg of ammonium sulphate, 119 kg of single super phosphate and 33 kgs of muriate of potash.

Irrigation: It is an important aspect in mulberry cultivation as it helps in dissolving the nutrients for its proper uptake by the plants. In order to maintain high moisture content in the leaves (80%), the chawki mulberry gardens are to be irrigated once in every 4 – 5 days, so that the soil remains wet and the leaf gets more water content. Irrigate the mulberry garden by making furrows at least 15 cm deep in between every paired row of mulberry and fill it with irrigation water. During rainy season the frequency of irrigation can be reduced as per the need. It has been estimated that 1.5 to 2 acre inches of water per irrigation is required. To save irrigation water micro irrigation system can be suitably adopted.

Pruning Schedule (8 crop harvest schedule / year): In an established one-year old chawki mulberry garden, the plants are to be pruned at crown height of 30cm above the ground, preferably during the onset of the monsoon. After 35 days of bottom pruning, harvesting of leaf is commenced for next 10 days. At the end of the rearing, the top terminal buds are clipped. 25 days after top clipping, the 2nd leaf harvest as shoot lets are carried out for rearing worms up to 2nd moult. Thereafter plants are again pruned at crown height of 30 cm above ground level (80th day after first pruning). This completes one cycle of ninety days and harvest of two crops. This cycle is repeated four times to get eight crops in a year.

Under this procedure, leaf harvest by individual leaf picking is recommended for 1st, 3rd, 5th and 7th crops. The terminal buds are to be clipped after individual leaf harvest. Shoot lets are to be harvested in 2nd, 4th, 6th and 8th crops.

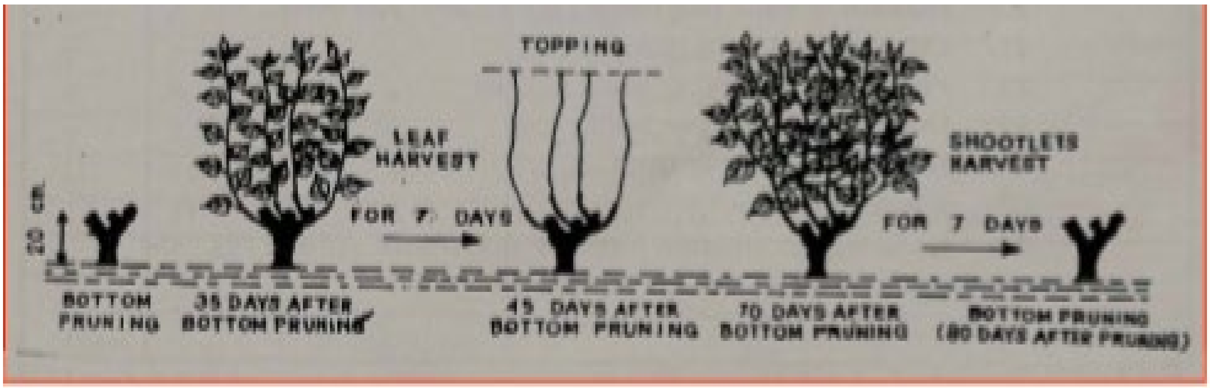

Fig. 7.2. Pruning schedule of chawki mulberry garden (8 crops schedule / year)

Table 7.1. Maintenance of Chawki mulberry garden

Days	**Activity**
0 days	All the plants are to be pruned 30 cm above the ground level.
1- 2 days	Maintain 10 – 15 healthy shoots and the weak branches needs to be removed.
3 – 5 days	FYM of 16 MT / acre / year in 4 split dosages @ 4 MT acre after every pruning. Irrigation is to be ensured in every 4 – 6 days.
14 days	Chemical fertilizers @ 260Kg (N) : 140 Kg (P) : 140 kg (K) / Ha / year in eight split dosages. 40 kgs of 17 : 17 : 17 + 13.5 kg Urea / acre/crop **Or** 45 kgs of 15 : 15 : 15 + 13.5 kg Urea / acre/crop **Or** 66 kg (Ammonium Sulphate) + 44 Kg Single super phosphate + 11.5 kg Murate of potash / acre / crop.
18 days	In case of Tukra or pest attack, 0.2% DDVP (2.5 ml / litre) is sprayed. The safety period to use the leaf is 15 days gap.
25 days	Spray of 1st dose of Seriboost @ 2.5 ml / litre (250 ml in 100 litres of water / spray / acre). It is a mixture of micro-nutrients and growth promoter.
32 days	Spray of 2st dose of Seriboost @ 2.5 ml / litre (250 ml in 100 litres of water / spray / acre).
38 days – 45 days	Brushing of chawki silkworms and leaf can be used upto 45th day.
46 days	Top clipping, digging and irrigation.
51 days	Application of chemical fertilizers as per the recommendation.
60 days	Spray of Seriboost as the above dosage.
67 days	Spray of Seriboost as the above dosage.
70 days – 78 day	Brushing and use of shoot lets for chawki rearing.
80 days	All the plants are to be pruned 30 cm above the ground level

Intercultural operations: After each pruning, ploughing has to be done to remove the weeds and to loosen the soil which stimulates the plant growth and facilitate the application of manures. The land should be ploughed along the mulberry rows as well as across the rows. It is better to provide one irrigation at least 4 – 5 days before each ploughing. Ridges and furrows are to be made to irrigate the garden.

As the weeds in mulberry garden competes for soil moisture and plant nutrients which reduces the mulberry leaf production and quality of leaf. Hence, the removal of weeds is very essential. Ploughing will uproot the weeds along with the roots and will be easy to remove with the help of garden implements. Weeds menace also can be reduced by spraying 0.71 % Glycel, a weedicide for killing the weeds.

Leaf harvesting and preservation: The leaves to be harvested will be from below the largest glossy leaf which is yellowish green in color. The cardinal point is shoot tips should not be removed during any leaf harvest. From the glossy leaf, about 3 leaves during the 1st(1-3) and about 3 leaves (4-6) during 2ndinstar can be harvested. Usually in cool hours (morning and evening) leaf harvest has to be done. The harvested chawki leaves should be preserved in cool and clean (hygienic) places in order to preserve their succulence.

Leaf Quality and yield: The leaves produced in a chawki plot are qualitatively superior with 80 % leaf moisture, 25 % of leaf protein and 13 % of leaf carbohydrates) as compared to the leaves from common garden. By adopting the recommended package of practices for chawki mulberry garden, it is possible to obtain the leaf yield of 30 – 35 MT / ha / year or 12MT of chawki leaf / / acre / year can be harvested.

Annually, approximate quantity of 1,60,000 Dfls / ha can be reared up to 2nd stage by adopting the recommended package of practices for chawki mulberry garden. In an acre of chawki garden approximately of 65,000 Dfls / acre / year can be chawki reared.

Management of chawki plot within the general garden: An area of about 100 sq.mts of the garden in one acre can be converted as a chawki plot within the existing general plot. About 277 plants can be accommodated in 60 x 60 cm and 123 plants in 90 x 90 cm spacing. These gardens need to be provided with provide additional input of FYM, irrigation etc.

The converted chawki plot is pruned 10 days after harvest and pruning of the general garden. Leaf harvest is done 35 days after pruning by which time the general garden will be of 45 days. Second pruning of chawki plot should be completed 10 days after the pruning of general crop.

Fig. 7.3. Chawki rearing garden

Fig. 7.4. Chawki rearing garden with rearing house

7.4. SUMMARY

The life cycle of silkworm consists of egg, larva, pupa and adult stages. Among these four stages, larval stage is the feeding and active stage. The young silkworms up to the end of second instar are called chawki worms and rearing of these worms is a vital aspect of sericulture industry for development of healthy silkworms and ultimately a successful cocoon crop can be harvested. Of the different factors responsible for healthy chawki rearing, leaf quality plays an important role. Moreover, the nutritional need of chawki silkworms is totally different from that of late age worms.

To ensure quality mulberry leaf for chawki silkworms, establishment of an exclusive chawki mulberry garden is quite essential. By ensuring the practice of recommended package of practices, it is possible to develop a chawki mulberry garden. One of the vital factors contributing to successful young age silkworm rearing is the supply of highly nutritious mulberry leaf. By providing this type of quality leaf, the young silkworms will be healthy, develop resistance to diseases and produce good quality cocoons. The quality of leaf used for young worms is of greater relevance in view of the influence of chawki rearing on the late age silkworms and ultimately the success of cocoon crop. This will ultimately help to develop sericulture industry by producing consistently successful cocoon crops.

GLOSSARY

Chawki Mulberry Garden:*A mulberry garden raised exclusively to obtain quality leaf for feeding young age / chawki silkworms.*

Chawki Rearing: *The rearing of young silkworm immediately after hatching from the eggs up to second moult.*

Chawki Rearing Center (CRC): *CRC is a place where a large quantity of young age or chawki silkworms are reared after hatching commercially with utmost care and delivered to the sericulturalfarmers after completion of second moult.*

Moulting *: The silkworms have five phases in larval stage andsilkworm enters from one phase to another by casting-off their old skin. While doing so, they stop eating leaf for certain period and cast-off their old skin. Immediately after passing off the stage they start eating once again.*

***Package of Practices**: A system of production of any agricultural plantation following certain accepted principles and technologies. For mulberry, it means a cultivation practice comprising a variety, a planting system, soil and plant nutrition management, irrigation, pest and disease management as well as crop harvest technique.*

***Paired Row System**: This is a planting system with wider spacing followed for mulberry growing under irrigated conditions. In this system, cuttings / saplings are planted at 60 cm between each other, while the distance between the two rows are maintained with a gap of 90 cm from each other. The distance between the two paired rows is maintained with a gap of 150 cm. It is the system facilitates partial mechanization.*

***Pruning**: A practice by which mulberry plants are cut and trimmed to maintain the proper structure and height of the plants to facilitate proper growth and yield.*

***Sapling** : It is a rooted cutting of specific age, that is, 100-120 days for low or high bush and about 240 days for small trees. Because of well-developed root system, saplings get established quickly and grow vigorously.*

***Tender Leaf** : The leaves which are produced in the mulberry plants at the apical / uppermost portion which are soft and succulent with high moisture content.*

***Weeding**: A practice by which unwanted plants growing along with mulberry are removed by digging land or using power tiller / tractor / country plough.*

I. Short Questions

i) What is the recommended dose of FYM to be used in an established chawki mulberry garden?

ii) What is the recommended dose of chemical fertilizers per acre to be used in an established chawki mulberry garden?

iii) How frequently the chawki mulberry garden needs to be irrigated?

iv) How many times are leaves harvested from a chawki mulberry garden in a year?

v) How much chawki leaf can be produced annually from one hectare of chawki mulberry garden?

vi) How many Dfls can be chawki reared annually from one hectare of mulberry garden?

II. Essay Questions

1. What is the importance of chawki mulberry garden? Give details of cultivation practices followed for a chawki mulberry garden?
2. Describe in detail about application of manures and fertilizers in chawki garden?
3. Explain in detail about the pruning schedule for eight crops schedule per year?
4. Write in detail about the maintenance of chawki mulberry garden?

Ψ

UNIT 8

Economics of Mulberry Cultivation

Structure

Learning objectives

After studying this, the student will be able to study;

- The economics of different farms.
- Different methods to reduce cost of economics.
- The economics of mulberry cultivated under rainfed and irrigated conditions
- The sericulture economics and cost benefit ratio of sericulture
- The cost of vermicompost production

8.1 Introduction

Sericulture has a good potential to generate attractive income for the farmers. It is an extremely labor-intensive industry and occupies a pivotal position from the point of providing employment and additional income to weaker sections. It has low capital requirement and serve as a good option for small farmers to gain meaningful employment and consistent / assured income throughout the year. In order to increase the profit, the production cost needs to be reduced to a reasonable extent. The farmers should be educated about the optimum use of inputs, such as fertilizers, pesticides and motivated to follow Integrated Nutrient

Management (INM), Integrated Pest Management (IPM) and Integrated Disease Management (IDM) approaches besides water conservation techniques.

Economics has been defined as the study of resource allocation under scarcity. Profitability from sericulture depends largely on the production of mulberry leaf at economic cost. Economics gives an idea of the margins of profits and loss related to an entrepreneurship. Every crop has its own economics and one should have the knowledge of economics of any farm before establishing. It has different perspectives which reflect on the net returns. Sometimes it may lead to loss if one has no idea about expenditure, cost of production, mainly input expenditure and cash returns. It indicates the difference between investment and profits. Generally, profits indicate the success of the farm. Any farmer is of the view to select a crop that generates more profits than the investment. Any entrepreneur wants to invest less in the form of physical labour, time, money etc., and tries to generate more income. It requires efficient management of human resources and natural resources.

In economic analysis of any enterprises, a comparison of costs with returns is done mainly to determine whether the enterprise is remunerative or not. The identification and calculation of costs and returns is important. While computing the cost of production for individual enterprises in farming, the costs are categorized into two groups namely fixed / non-recurring and variable / recurring costs. The total costs of cultivation comprise the total variable and total fixed costs. The distinction between fixed and variable costs is very important from the standpoint of decision making. Suppose if any farmer is venturing into sericulture afresh, all these costs are to be considered to evaluate the feasibility of investment. In case of a farmer who is already holding the mulberry garden and rearing shed but wants to decide upon the continuity then variable costs could be enough to decide upon the profitability of the enterprise.

8.2. Economics of Nursery

Mulberry is a vegetatively propagated perennial crop and in India propagation through cuttings is more common. Though mulberry plantation can be established by planting cutting directly in the field, using saplings has got more advantages over direct plantation of cuttings. Saplings are rooted cuttings used as planting material. Realizing the importance more and more farmers prefer saplings to establish their mulberry gardens. Though mulberry saplings can be raised throughout the year, it is recommended to raise the saplings 3 – 4 months prior to planting season i.e. February to April so that the saplings will be ready by June – August.

Table 8.1. Details for raising of mulberry nursery

Sl. No.	Details	Requirement
1	Extent	1 acre
2	Size of the nursery bed	3 mts. x 1 mts.
3	Number of nursery beds	1065
4	Spacing between plants	20 x 10 cm
5	Number of cuttings per bed	150
6	Total number of required cuttings	1.6 Lakhs
7	Expected recovery of saplings (%) @ 80% survival	1.28 Lakhs

Table 8.2. Expenditure for Land Preparation (1.28 lakh saplings / acre / batch)

S.No	Work Details	Expenditure (Rs.)
1	Two time ploughing (Tractor) 5 hrs work @ Rs 1000/hr	5,000
2	Ploughing with bullocks – 6 pairs @Rs. 700 per pair (two times)	4,200
3	Levelling, picking of weeds 10 mandays @Rs. 200/- per manday	2,000
4	Preparation of plots, channels – 30 man days @Rs.200 / manday	6,000
5	FYM 20 kg. per bed – 1092 beds, 22 MT @ Rs. 1500 / tone	33,000
6	Application of FYM, 10 man days @Rs. 200 / manday	2,000
	Total	**52,200**

Note: Values listed in the table may change according to place and season.

Table 8.3. Expenditure for cuttings and for plantation (1.28 lakh saplings / acre / batch)

S.No	Work details	Expenditure (Rs.)
1	Expenditure for plants, Rs. 2000 per tonne (approx. 30000 cuttings/ tonne) 6 tonnes	12,000
2	Transportation charges @ Rs. 1500 / ton	9,000

3	Cutting preparation @ 2500 cuttings/one mandays, 72 total mandays @ Rs. 200 Per manday	14,400
4	Fungicide and its application	3,000
5	Planting of cuttings @ 10 beds / 1 manday for 1065 beds 106 Mandays @ Rs. 200 per manday	21,200
6	Weeding @ 10 beds / 1 manday for 1065 beds/ 106 Mandays @ Rs. 200 per manday	21,200
7	Irrigation once in 5 days, per day -2 mandays- total of 50 mandays @Rs. 200 per manday.	10,000
8	Complex Fertilizer	2,500
9	Fertilizer application 6 mandays @ Rs. 200/-	1,200
10	Uprooting of saplings 100 mandays @ Rs. 200/-	20,000
11	Other expenditure (Insecticides, spray etc.)	5,000
	Total	**1,19,500**

Note: Values listed in the above table may change according to place and season.

Table 8.4. Economics of Mulberry Nursery (1.28 lakh saplings / acre / batch)

S No	Particulars	Cost (Rs.)
Variable costs		
1	Land preparation expenditure	52,200
2	Plants, Planting cost	1,19,500
3	Farm Implements cost (Approx.)	10,000
4	**Total**	**1,81,700**
Fixed costs		
5	Depreciation of equipment's	500
6	Rental value of land (Approx.)	25,000
7	Land Revenue	100
8	Managerial cost @ 10 % of working capital	18,170
9	**Total**	**43,770**
10	**Total costs / acre / year (4 + 9)**	**2,25,470**
11	Cost of production per one sapling (Rs.)	1.76
12	Total income (by the sale of 128000 saplings) @ Rs. 3/- per sapling	3,84,000
13	Net income for six months (Rs.)	1,58,530
14	Number of batches per year	2

15	Gross returns / acre / year (Rs.)	7,68,000
16	Net income per year (Rs.) / acre	**3,17,060**

Note: Values listed in the above table may change according to season and place

8.3. Economics of Mulberry cultivation under Rainfed conditions

Mulberry can be cultivated both under soil moisture stress / rainfed and irrigated conditions. Under rainfed condition, true moisture stress is experienced when annual rainfall is less than 700 mm with limited number of rainy days. Generally, the yield and quality of leaf are poor under such condition. However, specific package of practices for mulberry cultivation has been developed aimed at improving both the leaf and quality under such stress conditions. In earlier years, nearly one third of the mulberry area in south and central states belongs to this category. As such, at present in Southern India very few numbers of farmers are practicing under rainfed conditions in general and in Andhra Pradesh in particular. As the labour wages have gone up it is not economically viable under rainfed conditions with hired labout. It could be profitable if the family labour are involved in various activities of mulberry cultivation. The following is the economics of rainfed mulberry farm which is quite different from irrigated. Further, the cost of leaf production under rainfed conditions is comparatively higher than irrigated field.

Table 8.5. Establishment of One acre mulberry under rainfed conditions

S.No	Work Details	Cost (Rs.)
Land preparation		
1	Two deep ploughings by mould-board ploughs (tractor power) - 4 hours bullocks @ Rs.700/-	2,800
2	Disc harrowing (tractor power) 2 hours @ Rs. 700/- hour.	1,400
3	Final preparation of land 4 pairs of bullocks @ Rs. 700/- one pair of bullocks.	2,800
4	Digging of pits and application of FYM @ Rs.200/- for 80 mandays.	16,000
Planting material and plantation		
5	Two tonnes of cuttings @ Rs. 1600/-	3,200
6	Preparation of cuttings (14520 cuttings / acre @ 3 cutting / pit with a spacing of 3’ x 3’) and plantation @ Rs. 200/ manday for 30 mandays	6,000
Manures and Fertilizers		
7	4 MT of FYM @ Rs. 1500 / tone	6,000

8	Fertilisers 1st year NPK (20 : 10 : 10) 1st dose – NPK (10 : 10 : 10) Suphala (15 : 15 : 15) 66 kg of complex fertilizer @ Rs. 15/- & 2nd dose – N (10 Kg) – Urea 22 kg - Straight fertilizer @ Rs. 10/-	1,200
9	Inter-cultivation and weeding- 20 mandays for two times @ Rs. 200/-	4,000
10	Miscellaneous requirements	2,000
Total (Rs.)		**39,400**

Note: Values listed in the table may change accord to season and place.

The economics life of the plantation is over 15 years. Thus this amount is distributed over 15 years. Therefore the amount of annual cost to be added to cultivation expenses is Rs. 2627.

One year expenditure = 39,400/15 years = 2627/-

After plantation the crop is established within nine months thus one silkworm rearing can be planned during first year. The economics of cost of leaf production is as follows.

Table 8.6. Annual maintenance cost from 2nd year onwards / acre / year

S.No.	Work Details	Cost (Rs.)
1.	2 ploughings followed by each pruning - 2 pairs of bullock / one ploughing @ Rs. 700/ one pair of bullocks	2,800
2.	Harrowing-2 times, 2 pairs of bullock / one time @at Rs. 700/ one pair of bullocks	2,800
3	Weeding around the plants 4 mandays / one time for 5 times @ Rs.200/-	4,000
4	Fertilizers NPK / acre / year (40 : 20 : 20) 1st dose NPK (20 : 20 : 20) Suphala (15 : 15 : 15) – Complex fertilizer - 133 kg @ Rs. 15 /- & 2nd dose N (20 kg) - (Urea - (44kg) - Straight fertilizer) @ Rs. 10 /- kg	2,500
5	Application of fertilizers 5 mandays @ Rs. 200/-	1,000
6	4 MT FYM @ 1500/- MT and its application (2 mandays @Rs. 1000/-)	7,000
7	Intercultivation, 6 mandays @ Rs.200/-	1,200
8	Leaf harvest (50 kg / day / labour) for 4000 kgs leaf for 80 mandays @Rs. 200/-	16,000
9	Pruning 6 mandays / one time @ Rs. 200/ manday for two times	2,400

10	Miscellaneous expenditure	2,000
11	Non recurring cost	2,627
	Total (Rs.)	**44,327**

Note: Values listed in the table may change according to place and season.

In the rainfed garden by following the recommended package of practices it is expected to have 15,000 Kgs mulberry leaf per hectare per year. Hence, in an acre approximately a quantity of 6000 kgs of leaf can be harvested for year. Hence cost of one Kg of mulberry leaf is 44,327 / 6,000 = Rs. 7.38. This cost may considerably reduce in the subsequent years and later on it stabilizes the cost of production of mulberry leaf. The cost of production of mulberry leaf is higher than that of the leaf produced under irrigated conditions. With the productivity of 6000 kg mulberry leaf about 500 Dfls of Cross Breeds can be reared as the leaf quality is not fit for the rearing of bivoltines. Since the production of poor quality leaf, the estimated cocoon yield is 50kg / 100 Dfls. Even if, 50 kg yield per 100 Dfls (250 kg / 500 Dfls) and marketing of the cocoon @ Rs. 250/-, the revenue realized would be of Rs. 62,500. If approximately the rearing cost (Rs. 3000 / 100 Dfls) is also added along with mulberry leaf production cost (Rs. 44,327 + 15,000 + 2,627- non recurring expenditure) the total cost would amounts to be Rs. 61,954/-). Hence, it would not be economically viable under rainfed conditions.

Further the economics of mulberry cultivation under rainfed conditions indicates that, major amount is being invested on the labour for harvesting of leaf weeding, application of FYM, inter-cultivation and pruning of the mulberry garden which amounts to be 60 % of the total investment. Under such circumstances, if only family labour is involved it would be economically viable. Further it is also found that if labour cost is excluded, the cost of production per kilogram of mulberry leaf would be approximately of Rs. 2.95. Hence mulberry cultivation under rainfed conditions is economically viable when only family labour engaged for the mulberry cultivation and silkworm rearing activity. The leaf produced under such water stress conditions; the quality of mulberry leaf also is not up to the quality requirement of silkworm rearing. It is also being observed that, of late the monsoons are not seasonal and labour wages have gone up and sometimes their availability is also a problem. May be these are the some of the reasons for not practicing sericulture under rainfed conditions in the regions of Southern India in general and Andhra Pradesh in particular.

Table 8.7. Sericulture Economics under rainfed cultivation

Sl.No.	Particulars	Quantity	Amount (Rs.)
1	Mulberry leaf production cost	6000 kg leaf / acre	44,327
2	Rearing expenditure of 500 Dfls / 6000 kg of leaf (@1200 kg leaf / 100Dfls).	Rs. 3000 / 100 Dfls	15,000
3	Non – recurring expenditure		2,627
	Total rearing cost		**61,954**
Returns			
4	Sale of cocoons @ 50 kg / 100 Dfls (250 kg)	Rs. 250 / 1 kg CB	62,500
5	Sale of twigs (1 MT / year)	Rs. 2 / kg	2,000
		Total returns	**64,500**
	Net profit (Rs.)		**2546**

8.4. Economics of Mulberry cultivation under irrigated conditions

The mulberry leaf is the sole food of silkworm, *Bombyx mori* L. and the purpose of mulberry cultivation is to rear to silkworms. Hence the target is to produce more leaf per unit area making sericulture more profitable. In the present chapter initial establishment of mulberry garden is hypothetically worked out.

Table 8.8. Economics for establishment of mulberry garden through cuttings

Sl No.	Items	Amount (Rs.)
1.	Land preparation (cleaning, weeding & light digging), 20 Mandays @ Rs. 200/-	4,000
2.	Cutting preparation (In Row system) @ 3000 cuttings / manday; for 22220 Nos. cuttings @ 2 Nos. cuttings / pit (spacing 60 cm x 60 cm), 8 mandays @ Rs. 200/-	1,600
3.	Plantation of cutting @ 11 mandays @ Rs. 200/-	2,200
4.	Cost of manure (FYM) @ 8 MT / Acre /year @ Rs.1500/-	12,000
5.	Application of manure @ 6 mandays @ Rs. 200/ manday	1,200
6.	Irrigation @ 2 mandays /irrigation (Twice in a month for 4 months from Oct./ Nov. to February) - 8 times, 16 mandays @ Rs. 200/ manday	3,200
7.	Cost of irrigation bought by the farmers from others, as most of the farmers do not have pumps of their own (@ 6 hours for 8 times) @ Rs. 100 / hour	4,800
8.	Cost of mulberry cuttings (@ 1.2 MT per acre) @ Rs. 1700/ MT	2,040
9.	Miscellaneous expenditure	5,000
	Total (Rs.)	**36,040**

The economic life of mulberry plantation is 15 years. Thus this amount is distributed over a period of 15 years.

Thus one year expenditure = 36,040/15 =Rs.2402.

Table 8.9. Economics for establishment of mulberry garden through Saplings

Sl No.	Items	Amount (Rs.)
1.	Land preparation (cleaning, weeding & digging), 20 mandays @Rs. 200/ manday-.	4,000
2.	Pit making (35 x 35 x 35cm) for sapling plantation (@ 50 pits / manday for 10,890 Nos. pits), 218 mandays @ Rs. 200/- manday	43,600
3	Cost of 10, 890 saplings @ Rs. 3.00 / sapling	32,670
4.	Plantation of saplings @ 400 saplings per manday i.e. 50 saplings per hour, 28 mandays @ Rs. 200/-	5,600
5.	Cost of manure (FYM) @ 8 MT / acre/year @ Rs. 1500/-	12,000
6.	Application of manure @ 6 mandays @ Rs. 200/-	1,200
7.	Irrigation @ 1 mandays /irrigation (Thrice in a month for 4 months from Oct./ Nov. to February) - 12 times, 12 mandays @ Rs. 200/-	2,400
8.	Cost of irrigation bought by the farmers from others, as most of the farmers do not have pumps of their own (@ 4 hours for 12 times), 48 hours @ Rs. 100 / hour	4,800
9.	Cost of farm appliances	5,000
Total (Rs.)		**1,11,270**

The economic life of mulberry plantation is 15 years. Thus this amount is distributed over a period of 15 years.

Thus one year expenditure = 1,11,270 / 15

= Rs.7,418/-

Table 8.10. Recurring annual expenditure from 2nd year onwards (per acre / year)

Sl. No.	Items	Amount (Rs.)
1.	Digging & weeding @ 20 mandays per crop (5 crops / year), 100 mandays @ Rs. 200/-	20,000
2.	Application of Manure (FYM) @ 6 mandays @ Rs. 200/manday.	1,200
3.	Application of Chemical fertilizer @ 2 mandays / crop (5 crops /year) , 10 mandays @ Rs. 200/ manday.	2,000
4.	Irrigation @ 2 mandays /irrigation (Twice in a month for 4 months from Oct./ Nov. to February) - 8 times, 16 mandays @ Rs. 200/-.	3,200
5.	Cost of irrigation bought by the farmers from others, as most of the farmers do not have pumps of their own (@ 6 hours for 8 times), 48 hours @ Rs. 100/ hour.	4,800
6.	Shoot / leaf harvest @ 300 kg/manday, 53 mandays @ Rs. 200/-.	10,600
7.	Pruning @ 4 manday / crop (for 5 crop), 20 mandays @ Rs. 200/- .	4,000
8.	Cost of manure (FYM) @ 8 MT / acre/year	12,000
9.	Urea , 146 kg @ Rs. 10/-	1,460
10.	Single Super Phosphate (SSP), 75 Kg @ Rs. 10/-	750
11.	Muriate of Potash (MOP), 75 kg @ Rs. 7/-	525
12.	Azatobacter @ 1.6 Kg/ acre/year @ Rs.110/-	175
	Total (Rs.)	**60,710**

Generally the leaf production can be produced 24,000 kg / acre / year of land under irrigated conditions.

1. Cost of cultivation through plantation of cuttings

= [(Rs. 36,040.00 ÷ 15) + 60,710]

= Rs. 2,402 + 60,710 = 63,112

Average leaf production / acre / year = 24,000 kg

Hence the expenditure for production of 1 kg mulberry leaf = 63,112 / 24,000

= Rs. 2.63/-

II. Cost of cultivation through plantation of saplings:

= [(Rs. 1,11,270 ÷ 15) + 60,710]

= Rs. 7,418 + 60,710

= Rs. 68,128

Average leaf production / acre / year = 24,000 kg

Hence the expenditure for production of 1 kg mulberry leaf

= 68,128 / 24,000

= Rs.2.84/-

The economics of mulberry plantation in rainfed and irrigated cultivation per one acre is detailed above which shows a slight variation. The leaf production is high in irrigated than rain fed conditions. In recent years, with new the introduction of mulberry hybrids like V1, G2 and G4 and advanced methods of cultural practices, the leaf production has considerably increased up to 55000 to 60000 kg / ha / year and cost of production is still reduced.

8.5. Sericulture Economics / acre / year

With one acre of mulberry garden under irrigated conditions, a total of 1500 Dfls Cross Breed (CB) can be reared in a year Table 8.10. The sericulture economics has been calculated based on the leaf produced under irrigated mulberry established through saplings. It is estimated based on the rearing expenditure per 100 Dfls is Rs. 3500 / 100 Dfls which includes rearing facility, disinfectants, rearing material, mountages etc. Further, it is assumed to produce a total of 60 MT / ha / year with V1 mulberry variety.

The returns are calculated based on the average yield of 60 kg / 100 Dfls with Rs. 300 average price and left over mulberry twigs Rs. 3 / kg. The cost benefit ratio expected to be 1 : 1.50 under irrigated conditions with a net profit of Rs. 95,722 / acre /year . Hence, it is assumed that sericulture is to be quite remunerative venture for rural areas.

Table 8.11. Sericulture Economics / acre / year (irrigated conditions)

S. No.	Particulars	Rate (Rs.)	Amount (Rs.)
A. Expenditure			
1.	Cost of leaf production for 24 MT of leaf	2.84 / kg	68,160
2.	Cost of dfls (Multi x Bi.) 1500 dfls / acre /year	280/ 100 dfls	4,200
3.	Man days for rearing [@ 20 man days per 100 dfls (1500 dfls x 20 mandays)] year	200 / manday	60,000
4.	Rearing expenditure / for 1500 Dfls	3500/100 Dfls	52,500
5.	Non-Recurring expenditure (Plantation through saplings)		7,418
	Total Expenditure (Rs.)		**1,92,278**
B. **Return**			
6.	Returns @ 60 kg cocoons / 100 dfls (1500 Dfls x 60)	300/ kg	2,70,000
7.	Return from selling of left out mulberry twigs /branches etc. (6 MT / year)	3/ kg	18,000
Total Return (Rs.)			**2,88,000**
NET RETURN in Rs. : (B-A)			**95,722**
COST BENEFIT RATIO is 1 : 1.50			
ASSUMPTIONS			

Mulberry variety	V1
Silkworm Hybrid	Multi x Bi
Average leaf yield / acre @60 MT/ha/yr	24 MT / acre
No. of Dfls brushed /acre/year	1500 dfls
Rearing expenditure / 100 Dfls (Rs.)	3500
Average cocoon yield / 100 dfls	60 kg
Average price of cocoon / kg	300.00

8.6. Production of vermicompost

The earthworms being voracious eaters consume the biodegradable matter and give out a part of the matter as excreta or vermi-castings. The vermi-casting containing nutrients is a rich manure for the plants. There are about 350 species of earth worms in India with various food and burrowing habits. *Eisenia fetida*, *Eudrilus eugeniae* and *Perionyx excavatus* are some of the species that are reared to convert organic wastes into manure. Vermicompost, apart from supplying nutrients and growth enhancing hormones to plants, improves the soil structure leading to increase in water and nutrient holding capacities of soil. A growing number of individuals and institutions are taking interest in the production of vermicompost utilizing earthworm activity. Rural areas with predominance of agriculture, suburbs of cities and semi-urban areas are considered ideal locations for setting up of vermi-composting units on a larger scale from the view point of availability of raw material and marketing of the produce.

Components of a Commercial Unit : Commercial units have to be developed based on availability of cow dung locally. If some dairy is functioning then such unit will be an associated activity.

Sheds: For a vermi-composting unit, whether small or big, this is an essential item and is required for securing the vermi beds. They could be of thatched roof supported by bamboo rafters and purlins, wooden or steel trusses and stone / RCC pillars.

Vermi-beds: Normally the beds have 0.3 to 0.6 m height depending on the provision for drainage of excess water. Care should be taken to make the bed with uniform height over the entire width to avoid low production owing to low bed volumes. The bed width should not be more that 1.5 m to allow easy access to the centre of the bed.

Buildings: When the activity is taken up on a large scale on commercial lines, considerable amount may have to be spent on buildings to house the office, store the raw material and finished product, provide minimum accommodation to the Manager and workers.

Water Supply system: As the beds have to be kept moist always with about 50% moisture content, there is a need to plan for a water source, lifting mechanism and a system of conveying and applying the water to the vermi-beds.

Machinery : Farm machinery and implements are required for cutting (shredding) the raw material into small pieces, conveying shredded raw material to the vermi-sheds, loading, unloading, collection of compost, loosening of beds for aeration, shifting of the compost before packing and for air drying of the compost, automatic packing and stitching for efficient running of the unit.

Sl.No.	Particulars	Size / Quantity	Amount (Rs.)
1	Estimate for construction of temporary shed for setting up 200 TPA Vermi compost unit	8 mts. x 15 mts. x 5.4 mts	2,00,000
2	Implements & machinery Ex: Farm implements, Weighing machine, power operated shredder, sieving machine etc.		2,00,000
3	Water supply system		1,00,000
4	**Total operational cost** One cycle of 75 days		
5	Agricultural waste @ 320 kg per m3	105.6 tonne @ Rs. 200/-	21,120
6	Cow dung @ 80 kg/m3	26.4 tonne @ Rs. 1000/-	26,400
7	Worms @ 350 per m3 500 worms per kg	231 kg @ Rs. 100/-	23,100
8	Formation of vermibed with agro-waste, cow dung and worms	330 m3 @Rs. 100/-	33,000
9	Harvesting, sieving, packing, etc., including cost of bags	40 tonnes @ Rs 1/-	40,000
10	**Total operational cost / cycle**		1,43,620
11	Total cost of 5 cycles		7,18,100
12	Rent on lease		30,000
13	Total processing cost		**7,48,100**
14	**Total (1 +2 +3+13)**		**12,48,100**
15	Salary wages for 2 permanent skilled labourers @ Rs.10,000/month		2,40,000
16	Labour wages on day to day basis, 125 mandays @ 200/ man day		25,000
17	**Total cost of production(Rs.)**		**15,13,000**

Table 8.12. Estimate for production of 200 TPA (tonnes per annum) vermi compost unit

Table 8.13. Production cost and returns structure in vermicompost production

Sl.No.	Particulars	Quantity	Amount (Rs.)
1	Sale of vermicompost (200 MT)	Rs. 9000 / MT	18,00,000
2	Sale of earth worms	@5 Kg/ MT of compost and @ Rs. 300 / Kg for 200 MT production of compost	3,00,000
3	**Total Returns**		**21,00,000**
	Cost of production for 200 MT vermicompost		15,13,000
	Net profit (Rs.)		**5,87,000**

It is assumed that, from the second year onwards there will be 5 – 6 cycles with duration of each cycle at around 65-70 days. Further, taking into account various limitations and operational problems, the capacity utilization is further assumed at 50% in the 1st year and 100 % from 2nd year onwards (Table 8.13). Benefits include the income from sale of vermicompost @ Rs. 9000 per MT and earthworm @ Rs. 300/- per kg. The net income from the 2nd year onwards would be about Rs. 5,87,000 annually. Further it is assumed that the profit will increase in the subsequent years of production. In a nut shell manner for the production of one ton of vermicompost economics has been worked out in the Table 8.14.

Table 8.14. Cost of vermicompost production (Rs / ton)

Sl.No.	Particulars	Quantity	Amount (Rs.)
1. Variable costs			
A	**Material cost**		
	Agricultural waste & cow dung	1.47 Tons	2300
	Earth worms	1.99 kgs	600
B	**Labour Costs**	Rs. 200 / manday	
	Pit filling	3 mandays	600
	Worm separation	2 mandays	400
	Watering	3 mandays	600
	Collection of waste	1 mandays	200
	Sieving	2 mandays	400
C	**Interest on working capital**		500
		Total Variable costs (A + B + C)	**5200**
2. Fixed Costs			
a.	Land Rent		300
b.	Working Shed		800
c.	Tools and Machineries		1000
	Total Fixed costs		**2100**
	Total production cost		**7300**

SUMMARY

Economics gives an idea about margins of profits and loss related to a entrepreneurship. It indicates the difference between investment and profits. It requires efficient management of human resource and natural resources. Each and every aspect of cultivation has its own effect on the production which directly or indirectly influences the cost of production. The cost of production of mulberry nursery has been detailed per acre per batch. Under rainfed conditions, economics of mulberry cultivation in one acre of land has been worked out such as for establishment of mulberry garden and recurring expenditure required from 2nd year onwards. Further, the economics for establishment of mulberry using *cutting and saplings has been detailed separately and the recurring expenditure required from 2nd year onwards under irrigated conditions has been detailed in the chapter. Sericulture economics has been worked out per year per acre of mulberry garden under irrigated conditions. The cost of production for the 200 MT of vermi-compost has been worked out and also a detailed cost of production per one ton of vermi-compost.*

Practicals

1. Visit to nearby farms and estimate the economics of mulberry gardens and mulberry nurseries.
2. Interact with a sericulture farmer and work out the economics per acre per year.
3. Visit to a vermi-compost unit and find out the cost of production by interacting with an entrepreneur.

QUESTIONS

I . Short Questions

1. On what basis the economics of a farm can be assessed?

2. When do you say that economics of mulberry farm is good?

3. Mention some of the recurring expenditure items?

4. What is the expenditure incurred for establishing mulberry farm?

5. How do economic details help the farmer?

II. Essay Questions

1. Write in details about the expenditure needs to be incurred for establishment of rainfed mulberry garden?
2. Give in details about the economics of establishment of mulberry nursery in one acre of land?
3. Write about the economics of establishment cost of one acre of mulberry through saplings under irrigated conditions?.
4. Write in detail about the cost of production for one ton of vermicompost?

References

1. Biotechnology (2005), V. Kumaresan published by Saras Publication, Nagercoil, Tamil Nadu.
2. Silkworm Breeding & Genetics (2005) published by Central Silk Board, Bangalore.
3. Sericulture Extension Management & Economics (2005) Published by Central Silk Board, Bangalore.
4. Principles and Techniques of Silkworm Breeding (1997), printed by Oxford & IBH publishing Co. Pvt. Ltd.

5. Status papers during Seri-Breeder's Meet (2018), Published by Central Silk Board, Bangalore.
6. Mulberry cultivation & Physiology (2005) by L. Rajanna, PK Das and S. Ravindran, Published by Central Silk Board, Bangalore.
7. Text book for A.P., Intermediate First Year (Botany), Published by Board of Intermediate Education, Andhra Pradesh.
8. Appropriate Sericulture Techniques (1987), Manjeet S.Jolly, CSRTI, Mysore.
9. New Technology of Silkworm Rearing (1990), S. Krishnaswamy, CSRTI, Mysore.
10. An Introduction to Sericulture (1995), Ganga &SulochanaChetty, Oxford & IBH Publishing Co. (P) Ltd., New Delhi, 1995.
11. Pattuparishrama (Intermediate) (1996), P. Srinivas, Telugu Academy, Hyderabad.
12. Text Book of Tropical Sericulture (1975), Japan Overseas Co-operation Volunteers, Japan.
13. Bulletins on Sericulture, CSB, Bangalore.
14. Hand Book on Pest and Disease Control of Mulberry and Silkworm (1990), ESCAP. United Nations, Thailand.
15. Lecturers on Sericulture by Boraiah (1994), SBS Publishers, Bangalore.
16. Global Silk Secnario-2001 (1996) by CSB, Oxford & IBH Publishers, Bangalore.
17. Organic sericulture for global bivoltine productivity (2015) by Susheelamma shivappa, Studium Press LLC, USA.
18. Sericulture Field guide (2012), Edited by Dr. GV Prasad, Dr. T. Mogili, Dr. M. Raghupathi and Ch. Satyanarayana Raju, published by Central Silk Board, Bangalore.
19. Pattuparishrama saanketika vignanakaradeepika (2016), published by Central Silk Board, Bangalore.
20. Pattu Vignana Karadeepika (2016) by Dr. P.J. Raju, Dr. S.V. Seshagiri and Y. UmamaheswaraRao, published by the Director, APSSRDI, Hindupur.
21. **Sericulture Industry**: A Bonanza to Strengthen Rural Population in India (2017) by P.J. Raju, D.M. Mamatha and S.V. Seshagiri. Published in *Handbook of Research on Science Education and University Outreach as a Tool for Regional Development by IGI Global, USA.*

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SERICULTURE

Paper – II

Silkworm Seed Technology

INDEX

UNIT 1

SYSTEMATIC POSITION OF *BOMBYX MORI* L.

Structure

1.1 Introduction
1.2 Systematic position and classification
1.3 Types of silkworm
1.4 Summary

Learning Objectives

- Classification of silkworm characteristics.
- Systematic Position of Bombyx mori.
- Types of mulberry and non-mulberry silkworms.

1.1 **Introduction**

In India, all the four types of silkworms are being exploited commercially. They are, Mulberry, Tasar, Eri and Muga silkworms. Except mulberry silkworm, all others are considered as wild types. Mulberry silkworm is a domesticated variety which has been exploited for over 4000 years. Generally, the term silk refers to Mulberry silk, because it contributes to 95% of world silk production. All the strains or races reared at present belong to the species ***Bombyx mori*** **(L).** It Produces Cocoons with continuous filament and it can be industrially reeled to produce raw silk.

Silkworm, being a cold-blooded animal, duration of each life stage, growth factors, feeding schedules are completely depend on the environmental factors like temperature, humidity, rainfall, light and air. Further the insect's racial characters also play vital role to overcome all these natural hazards. However, life cycle may be delayed due to the above said factors and some may die without metamorphosis. The chromosomal studies revealed that *Bombyx mori* has evolved from *Bombyx mandarina*. The domestic silkworm has undergone a variety of genetic mutations like the ancestor silkworms.

1.2 Systemic Position and Classification

The characteristic features of Phylum Arthropoda appeared in Silkworm *Bombyx mori* L. are as follows.

Silkworms are classified on the basis of native regions, the number of hatchings in a year i.e. voltinism, moulting, rearing period, body markings, body colour of freshly hatched larva, body colour of mature larva, colour of cocoon, colour of egg etc. But the taxonomic classification is based on the significant evolution of the organisms. It considers the body form, organ system, genetic traits etc.

- Silkworm belongs to the class Insecta, Phylum Arthropoda because the insect body is divided into Head, thorax and abdomen. The body has specific number of segments. A typical insect has six segments in head, three in thorax and eleven in the abdomen. The head segments are completely fused during embryo stage to form a head capsule.
- The other two body divisions possess moveable segments. These insects may or may not have jointed appendages and may also possess one or two pairs of wings.
- Insecta is divided into sub classes Apterygota and Pterygota. The silkworm comes under sub-class Pterygota. The sub-class Pterygota is divided into two divisions namely Exo-pterygota and Endo-pterygota. The silkworm comes under division Endo-pterygota. These two are further formed into different orders.
- The mulberry silkworm is included in order Lepidoptera by possession of two membranous wings with few cross veins, flat scales on the body and appendages. The larval stage caterpillar with three pairs of two legs, five pairs of pseudo legs.
- The different kinds of silkworms are placed under super family *Bombycoidae* on the following characters
- Maxillary palpi and Tympanal organs absent
- Fraenulum (wing – locking apparatus) atrophied or vestigial.
- Proboscis absent.
- Chaetonema absent.
- Antenna pectinated especially in males.
- The ***Bombycoidae*** consists of eight families of which ***Bombycidae*** and ***Saturnidae*** includes the economically important insects, which produce natural silk of commercial value. Mulberry silkworm comes under the family ***Bombycidae.***

➢ The wild silkworm name ***Bombyx mandarina*** is the ancestor of Mulberry silkworms. ***Artocarpus incises*** is the ancestor of both *Bombyx mori* and *Bombyx mandarina*.

- The *Bombycidae* includes domesticated silkworm along with ancestor stock, while Saturnidae includes wild silkworms.

Bombycidae

a. ***Bombyx mori*** : The domesticated silkworm
b. ***Bombyx mandarina***: Wild ancestor of commercially cultivated silkworms

Saturnidae

a. ***Antheraea pernyi***- Chinese tasar silkworm
b. ***Antheraea mylitta*** - Indian tasar silkworm
c. ***Antheraea yamamai*** - Japanese tasar silkworm
d. ***Antheraea Assama***- Indian muga silkworm
e. ***Philosamia ricini***- Eri silkworm
f. ***Philosamia Cynthia***- Wild species of e
g. ri silkworm

Classification of Silkworm

Phylum	-	Arthropoda
Class	-	Insecta
Sub-Class	-	Pterygota
Division	-	Endopterygota
Order	-	Lepidoptera
Super Family	-	Bombycoidae
Family	-	Bombycidae
Genus	-	*Bombyx*
Species	-	*Mori* (L)

1.3 Types of silkworms

There are mulberry and non-mulberry silkworms. Besides this 400 to 500 varieties of non-mulberry silkworms are reared by Tribal's of Asia and Africa. India is the only country to produce all the four types of silk, *i.e.* Mulberry, Tasar, Eri and Muga. The following are the different types of silkworms.

1.3.1 Mulberry silkworm

Bombyx mori L. is domesticated silkworm, feeds on mulberry leaves belonging to family *Moraceae*. These are classified and identified as univoltine, bivoltine and multivoltine races and they are of pure and hybrid strains. These worms are have been reared in dwelling and separate rearing houses.The worms produce long, continuous silk filament which is white or light yellow in colour. The silk has good commercial value.

1.3.2 Tasar silkworm

Tasar silkworms are of three types.

- ***Antheraea mylitta*** - Feeds on *Terminalia tomentosa* and reared in India
- ***Antheraea proylea*** -Feeds on Oak leaves and reared in India.
- ***Antheraea yamamai***-Feeds on Arjun, Sal, Oak, and Plum, reared in Japan.

These are Uni or Bivoltine types.Cocoons are big in size and weigh about 7-14 grams with a peduncle and reeled to get 1000-1200 meters of fiber. Cocoons are yellow, light yellow, purple, brown, gray in color. These silkworms are found in Godavari river belt of Andhra Pradesh. The silk is highly valued for its quality.

1.3.3 Eri silkworm

The scientific name of Eri Silkworm is ***Philosamia ricini*** and it is a domesticated silkworm, reared on Castor and Tapioca leaves.It produces a white or brick-red Silk.The cocoons are very weak and pediculate.The Eri silk filament is neither continuous nor uniform in thickness, thus cocoons cannot be reeled. Therefore, the moth emerged from cocoons are used for to extract silk by process of spinning but not reeling. So the pupae are not killed, so called as ‘ahimsa silk’.It is found in Assam, Bihar, West Bengal, Manipur, Odisha and Tripura.

1.3.4 Muga silkworm

The scientific name of Muga Silkworm is ***Antheraea assamensis*** feeds on Som and Soalu leaves to produce Golden – yellow silk thread which is very strong and attractive.It is the unique monopoly of India found in Brahmaputra Valley and adjoining hills in Assam.The rearing is done outdoors.The cocoons peduncle is weak and is of different in size and colour with continuous silk fiber. The moth emerged cocoons used to extract silk.

1.3.5 Anaphe silkworm

Anaphe is a polyphagous Insect and feed on 22 varieties of food plants.It is a univoltine silkworm which is green in colour. A unique feature is that its silk nest and moths are never severely affected by the parasitism. The silkworm of genus *Anaphe* is found in southern and central Africa which produces the silk. Approximately 12-100 larvae form collective cocoons (spin in communes) enclosed by thin layer of silk.The cocoon is brown with 10-15 cm length,5-12 cm thick and 10-21 cm width. Each Cocoon weighs 3.5 kg and it takes 3-4 months for spinning.This soft and fairly lustrous silk is more elastic and stronger than mulberry silk. The silk is used in velvet and plush (crafting, needlework) making.

1.3.6 Fagara silkworm

Fagara silk is obtained from the giant silk moth ***Attacus atlas*** L. inhabiting the Indo-Australian bio-geographic region, China and Sudan. It belongs to the family *Saturniidae*. It is the largest of the living insects reaching up to eleven inches in wing-span. The *Fagara* cocoons which are light-brown in colour measuring about 6 cm long with peduncles of varying lengths (2 – 10 cm) are less important since the silk is not commercially exploitable.

1.3.7 Coan silkworm

Coan silk fibre is secreted by the larvae of *Pachypasaotus D*. These larvae are found in the Mediterranean bio-geographic region (Southern Italy, Greece, Romania and Turkey etc.). This is a polyphagous insect feeding on pine, ash, cypress, juniper and oak. The cocoons are white in colour. The cocoon measures about 8.9 cm x 7.6 cm. In ancient times, this silk was used to make crimson dyed apparel worn by the dignitaries of Rome. The commercial production came to an end because of limited output and cost of production.

1.3.8 Cricula silkworm

This polyphagous insects feed on ten types of plants. It is found in Kishangunj area of Bihar on mango trees during August – December. The cocoons weigh approximately 2.12 gr.

1.3.9 Mussel silkworm

Mussel silk, a non-insect type of silk is obtained from a particular bivalve mollusc like ***Pinna squamosa***.They are found in the shallow water along the Italian and Dalmatian shores of the Adriatic. The fibre is called byssus thread, which is brown in colour, strong in quality and keeps the animal to anchor itself to a rock or any surface of the habitat. The byssus is combed and then spun into a silk popularly known as fish-wool .Its production is largely confined to Toronto of Italy.

1.3.10 Spider silkworm

The spider silk is a non-insect variety. The soft and fine spider silk is noted for its strength and elasticity. The commercial production is obtained from Madagascar species. The accumulated fibre formed by a dozen spiders is reeled out four or five times a month. Because of high cost of production this silk is not used in Textile Industry, but it is used as gill nets, dip nets, kite nets and various lures for the fishing activities and also for weaving bags, caps and head dresses.

1.4 SUMMARY

- The term silk refers to mulberry silk which contributes to 95% of world silk production.
- ***Bombyx mandarina*** is the ancestor of silkworms.
- ***Artocarpus incisus*** is the ancestor of both *Bombyx mori* and *Bombyx mandarina*.
- The classification is based on evolution of organisms in body form, organ systems, genetic traits etc.
- The silkworms belong to Phylum: *Arthropoda*, Class: Insecta, Order: Lepidoptera.
- The different kinds of silkworms are placed under super family *Bombycidae* and *Saturniidae*. These two cover commercially important silk producing insects.
- Mulberry silkworm is widely cultivated in 29 countries.
- Tasar cocoon are big weighing 7-14 gms with a peduncle and possess 1000-1200 mts. of silk fibre.
- Eri produces white or brick red colour silk while Muga gives unusal golden yellow silk which is very strong and attractive.
- Anaphe silk is produced by 12-100 larvae collectively.
- Fagara, Coan, Cricula contribute very less silk production.
- Mussel (a mollusc) and spider silk are non-insect silk.
- Mussel silk is called as fish-wool.
- A dozen of spiders collectively form cocoons.

Questions

I. Short Question

1. Write the classification of *Bombyx mori*.?
2. Name some of the non-mulberry silkworm?
3. Mention the non-insect silk producers.
4. Write the scientific names of any four silkworms.
5. What do you mean by spinning in communes?
6. Mention the ancestor of silkworm.
7. Mention the ancestor of *Bombyx mori* and *Bombyx mandarina*.
8. What does the term silk refers to?
9. Name some of the Chief food plants of silkworms.
10. Name the cocoons that can be reeled and spunned.

II. Essay Questions

1. Write a brief note on classification of *Bombyx mori L.*
2. Write in detail about the importance of non-mulberry
3. Explain the different types of silkworm.

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UNIT 2

MORPHOLOGY AND LIFE CYCLE OF *BOMBYX MORI* L.

Structure

Learning Objectives

1. Life cycle of silkworms
2. Morphological characteristic features of silkworm, Egg, Larva, Pupa and adult
3. Definition of metamorphosis

2.1 Introduction

Morphology is the study of external characters of an animal. It helps us to identify the animal and also to know the different functional significance of the organs (or) structures found. The domestic silkworm undergoes complete metamorphosis (Holometabola) and passes through four morphological stages *i.e.* egg, larva, pupa and adult. The fundamental knowledge of rearing silkworms for reeling cocoons is to learn the morphology and physiology of silkworm life stages and their importance.

2.2 Study of life stages and cycle

Out of these four stages larval period continues for several days at the silkworm larvae spin cocoon first prior to pupation. The morphological features of these stages are as follows.

2.2.1 Egg stage

The silkworm eggs are tiny and weigh around 2000 eggs to a gram. It measures 1-1.3 mm in length and 0.9 – 1.2 mm in width. The size, weight, shape, colour of the egg, number of eggs per laying vary among the different races and according to the season. The eggs of European races are comparatively larger and heavier. An average Indian cross breed multivoltine races lays approximately about 400 eggs per laying.

The Eggs are ovoid, ellipsoid or oval and flat on one side. This is called **egg dimple.** The egg colour also depends upon a racial character. Races producing white cocoons lay pale yellow eggs while yellow cocoons lay deep yellow eggs. The Japanese races lay slightly darker eggs than Chinese races. In diapausing eggs, the egg colour changes after 24 hrs of egg laying and becomes dark brown or purple with deepening of the colour of the seasonal pigment, but in non –hibernating eggs the colour does not change. The protective covering of the egg is called **Chorion,** which has an opening called **micropyle** at the anterior end. (Fig 2.1)

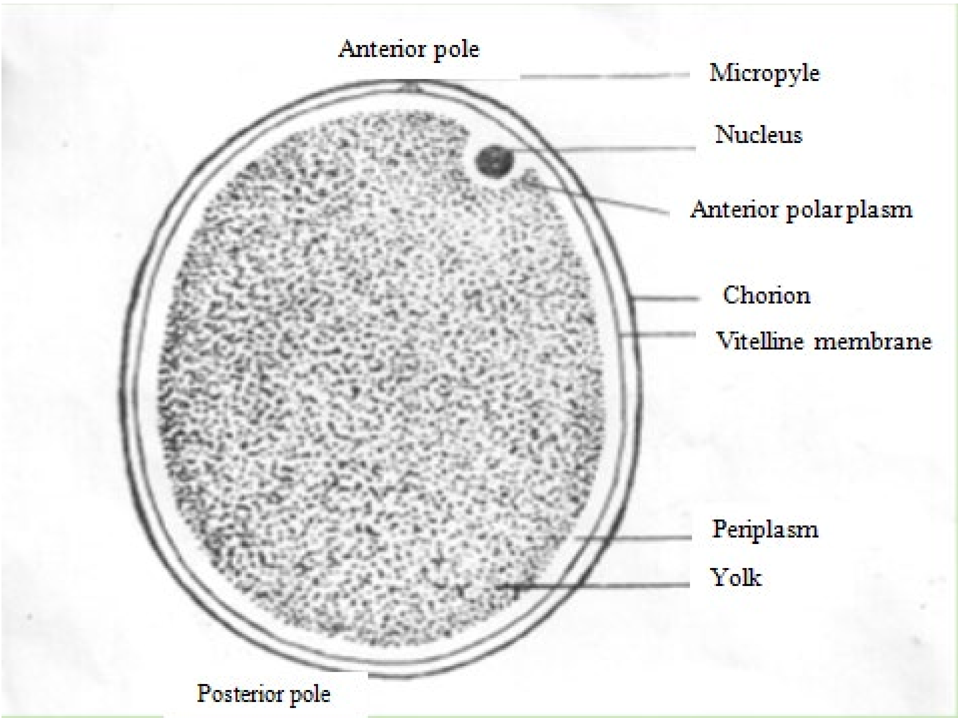


Fig 2.1. Structure of silkworm egg

There is a thin membrane called Vitelline membrane inside the chorion. The vitelline membrane covers the protoplasm and the yolk. The yolk is not present throughout the egg but present just below the vitelline membrane. A thin layer of cytoplasm does not contain the yolk and this portion is called the Periplasm which is particularly thick around the micropyle. This area is called an anterior polarplasm and contains the egg nucleus.

2.2.2 Larval stage

The newly hatched larva is black or dark brown in colour measuring about 3 mm in length. It is commonly called as **Ant** or **Kego.**

The head is large and the body is densely covered with bristles. There are four pairs of tubercles i.e., sub dorsal, supra spiracular, intra spiracular and basal tubercle each carrying 3-6 setae. As the larva grows by passing moults to enter into later instars the body becomes smooth and light in colour due to rapid stretching of cuticular skin. The body has 3 divisions i.e., head, thorax, and abdomen. The thin elastic chitinous cuticle permits rapid growth of the larvae during any instar (Fig 2.2)

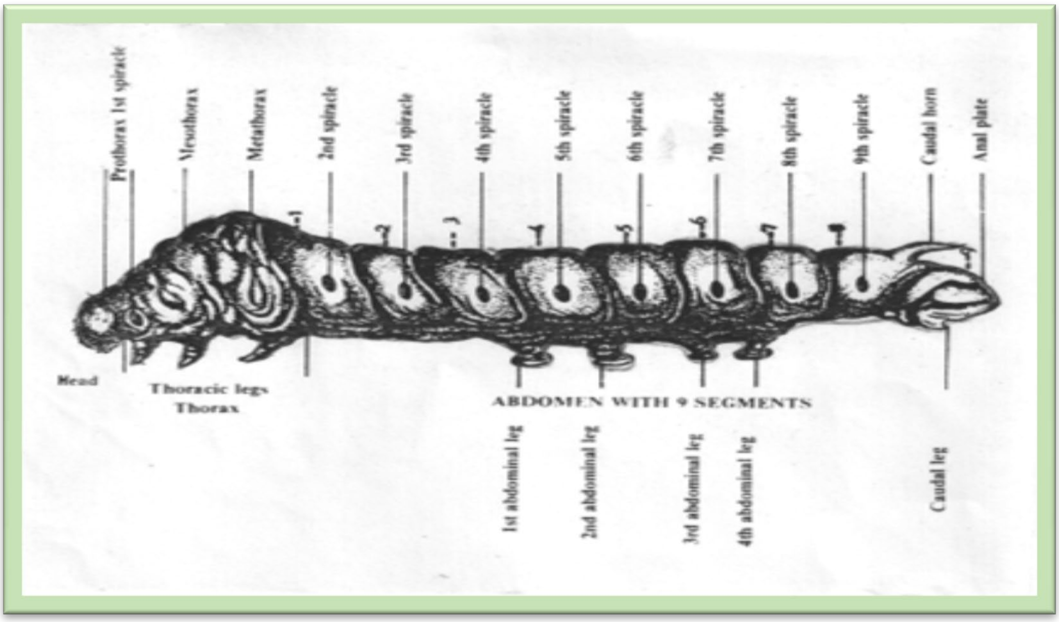


Fig 2.2. Morphology of silkworm Larva

2.2.2.1 Head

The head consists of six body segments fused together with a cranium. The 2nd, 4th,5th and 6th segments carry appendages which are modified into antennae, mandibles, maxillae and labium respectively. Median epi-cranial stature is well developed and prominent. Similarly on the outside, the clypeus and the labrum are also prominent. There are six pairs of ocelli or larval eyes which are located behind and a little above the base of the antennae. There is a pair of antennae formed of five jointed segments and they are used as sensory organs (feelers). The mandibles are well developed, powerful and are adapted for mastication (fig 2.3).

The maxilla on the ventral side of the mouth consists of cardo, stipes, maxillary lobe and maxillary palpi. Maxillary lobe and Maxillary palpi discriminate the taste of food. The labium is located ventrally carrying a big-sized lightly chitinized mentum. The prementum is chitinized and black. Distally the prementum carries a median process or spinneret through which silk is expelled from the silk gland to form the silk bave or thread to form cocoon. The sensory labial palpi are found on both sides of the spinneret.

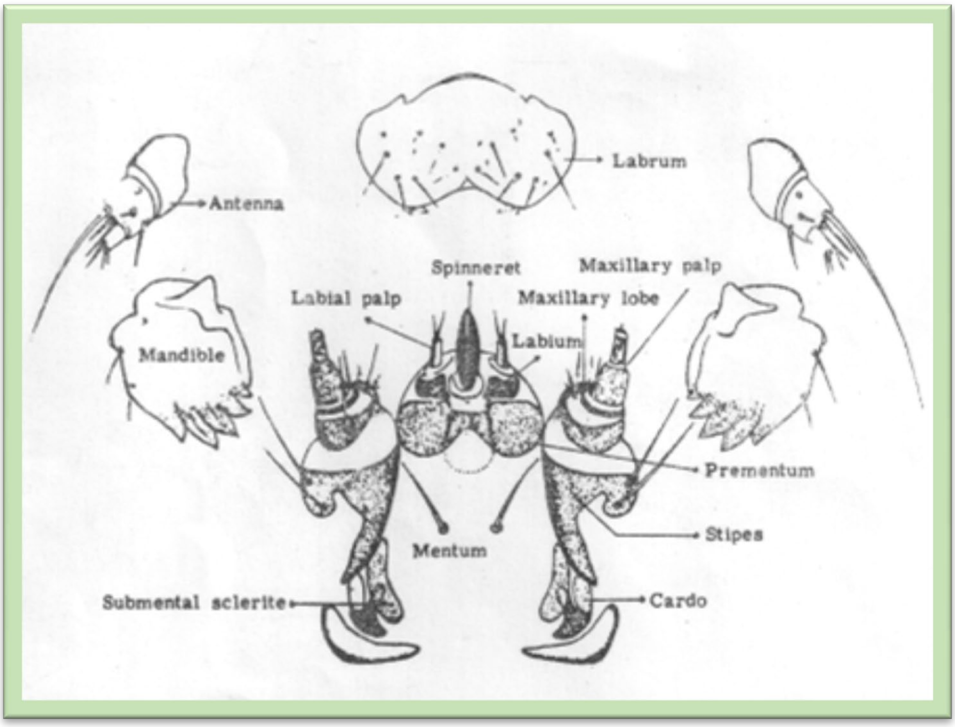


Fig 2.3. Mouth parts of silkworm larva

2.2.2.2. Thorax

Thorax consists of three body segments called the pro-meso and meta-thorax. Each of the three thoracic segments carries ventrally a pair of legs each comprising in turn three jointed segments. These are the true legs which are conical in shape and carry sharp distal claws. These claws are not used for crawling but are used for holding mulberry leaves while feeding. Silkworms contain eye spot (spiracle) on the dorsal side of the meso-thorax.

2.2.2.3 Abdomen

The abdomen is comprised of eleven body segments although only nine can be distinguished and the last three are fused together to form the apparent ninth segment, the anal plate and the caudal legs. The third to sixth and the last abdominal segments bear a pair of abdominal legs in each segment which are fleshy, unjointed muscular protuberances. At the extremity they form a sort of disc with a series of hooks inwardly curved and arranged in a semi-circular fashion. On the dorsal side of the eighth abdominal segment, the larva carries the caudal horn.

Spiracles (respiratory pores)

On either sides of the silkworm body there are nine pairs of spiracles placed laterally. They are found on the first thoracic segment and the first to eighth abdominal segments. These are the breathing or respiration pores.

Larval skin

The larval skin or integument consists of the cuticle and the hypodermis. The cuticle is made of chitin as well as protein and is covered with a thin layer of wax. Nodules are found all over the body surface of the silkworm larva. The distribution of the nodules differs according to the variety of silkworms. The larval markings in silkworms are caused by skin pigment.

2.2.3 Pupal or chrysalis

The pupal stage is generally called the resting, inactive stage of the silkworm when it is incapable of feeding and appears motionless. This is a misnomer. The pupal stage is a transitional phase during which definite changes take place. During this period of biological activity the larval body and its internal organs undergo a complete change (Metamorphosis) and assume the new form of the adult moth. The mature silkworm larva passes through a short transitory stage from pre-pupa to a pupa stage. During the pre- pupa stage the dissolution of the larval organs takes place and this is followed by the formation of the adult organs during the pupa stage. Soon after pupation the pupa is white in colour and soft but gradually turns brown to dark brown and the pupa skin harden. (Fig 2.5) The prominent morphological parts visible are a pair of large compound eyes, a pair of large antennae, fore and hind wings and the legs. Ten of the abdominal segments are seen on the ventral side when nine are seen from dorsal side. Seven pairs of spiracles are found in first seven segments and last pair is non-functional.

2.2.4 Adult stage

The adult moth emerging from the pupa is incapable to fly.It does not feed during its short adult life. The body of the moth is composed of three distinct segments i.e.,Head,Thorax and Abdomen. The adult body surface is covered with scales (Fig 2.6).

Head

The compound eyes are situated on the either side of the head. The ocelli are absent. The antennae are conspicuous, large and bi-pectinate.

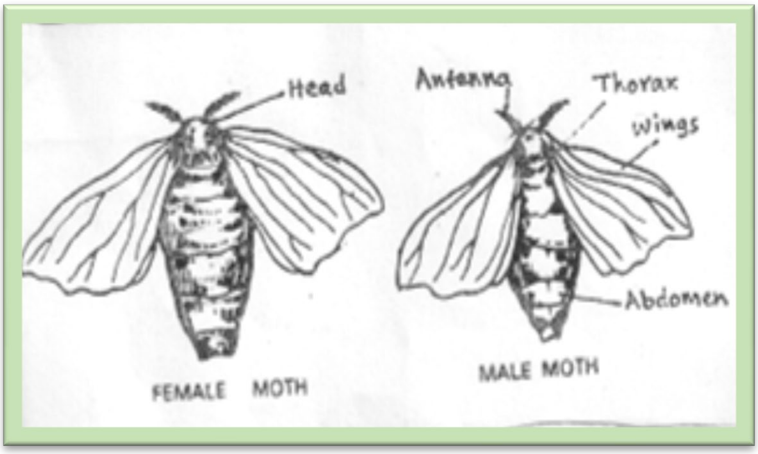


Fig 2.6. Male and Female adults

Thorax

The thorax consists of three segments namely pro, meso and meta thorax. The meso thorax is the largest and is pentagonal. There are three pairs of thoracic legs, one pair on each of the three thoracic segments. Each of the thoracic leg consists of five segments. The meso and meta thorax bear two pairs of wings, the front pair overlapping with the hind pair when the moth is in the resting position.

Abdomen

In the male adult eight abdominal segments are visible where as in the female seven segments. There are six pairs of spiracles present laterally on either side of the body.

2.2.5 LIFE CYCLE

2.2.5 Stages of Life Cycle

The silkworm passes through four important stages (Egg, Larva, Pupa, Adult) during its life cycle (Fig 2.8). The life cycle is completed in six to eight weeks depending on climatic and racial characters. In nature univoltine, bivoltine, multivoltine races are confined to different bio-geographical parts. Among them multivoltines of tropical areas have the shortest life cycle. The univoltine races produce only one generation in summer and the second generation Eggs undergoes hibernation till next spring. In Bivoltine races the third generation eggs undergoes hibernation thus producing thus only two crops in a year. In the case of multivoltine are non- hibernating thus yields as many as seven to eight generations in a year in tropical sericulture areas. The multivoltine races have the shortest life cycle because of warmer ecological conditions and the rearing activity continues throughout the year.

Table 2.1. Duration of Life Stages of uni,bi and multivoltine races of *Bombyx mori.*

Stage	Univoltine	Bivoltine	Multivoltine
Embryonic Period	11-14 days	11 - 14 days	9 - 12 days
Larva	24 - 28 days	24 - 26 days	20 - 24 days
Pupa	12 - 15 days	12 - 15 days	10 - 12 days
Adult	6 - 10 days	6 - 10 days	3 - 6 days

2.2.5.1 Egg stage

The duration of egg stage in the life cycle depends on diapausing or non-diapausing eggs. The diapausing eggs remain dormant under natural conditions for months together till spring of next year. This diapause can be broken artificially by acid treatment, after which eggs are incubated at a constant temperature for 11-14 days for hatching. The temperature (24-25^{o}c) provided during incubation favour the embryonic development of the egg to larva. While the non-diapausing eggs normally hatch in 9-12 days period. These eggs can also be preserved for next year by postponing the embryonic development by various cold preservation schedules.

2.2.5.2 Larval stage

This stage is important to the silkworm rearers since the complete crop yield depends on the various physiological processes of the larva. The larval life may last from 20-24 days in multivoltine species in tropical areas or 24-28 days in uni and bivoltine races in temperate areas. The larval life of the silkworm is divided into five respective stages known as 5 Instars and 4 moults, so as to accommodate the growth that takes place in each instar, the feeding period. Thus the larva casts off its skin and develops a new one to enter into succeeding instar.Most of the silkworm races are tetra moulters. Silkworm larvae start feeding on mulberry leaves soon after hatching. After reaching the certain growth first moult and second instar, second moult and third instar, third moult and fourth instar, fourth moult and fifth instar occur.

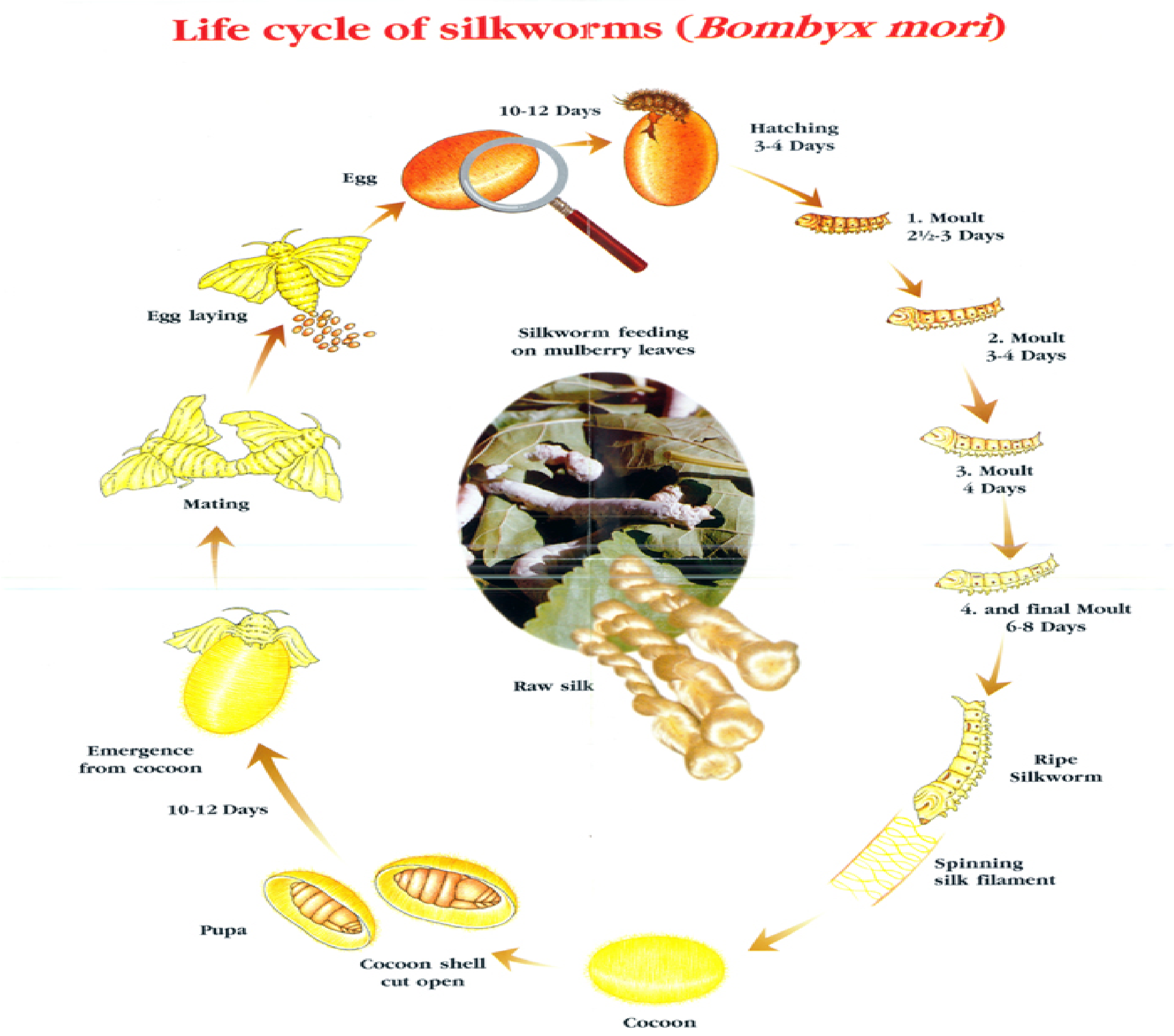
During this long period of feeding the larvae grows to 8,000 to10,000 times compared to newly hatched worm. However the weight gain varies with the silkworm variety, besides nutritional condition. The first three instars are referred as “young age” or “Chawki worms” and fourth and fifth instars as “late age” worms.

2.2.5.3 Moulting

Moulting refers to shedding of old skin and forming new skin. Each larval instar has feeding phase and moulting phase. Since the larval period is the active and feeding stage it enables to build up the energy reserves for the next life stages. After feeding voraciously and having attained full growth for the particular instar the silkworm lose its appetite and the larva prepares to moult and cast off its old skin. Each moulting period lasts for 15 to 30 hrs. The first moult is the shortest than remaining. The moulting is a physiological process under the control of ecdysone hormone while the active feeding period is administered by juvenile hormone.

2.2.5.4 Mature worms

After passing four moults the larvae reaches fifth or final instar, which continues for 6-8 days and larvae are fully matured and ready for mounting. At this stage the larvae loose appetite, stops feeding and excretes soft faeces and urine with high moisture content and turns to golden yellow colour ripen worm starts spinning the cocoon.



2.2.5.5 Cocoon-pupa

The mature and ripen worms spin the cocoon immediately after mounting and completes the process in 48-72 hrs. In another day or two the worm transforms into pupa within the cocoon.

Pupa is an inactive stage where the larval structures degenerate and adult structures differentiate. The pupal period may last for 8-14 hrs. The differentiated adult emerges slitting through the pupal skin and piercing the final fibrous cocoon shell by releasing a mild protease.

2.2.5.6 Adult moth

Adult moth exhibits sexual dimorphism like larvae and pupa. These moths are ready to copulate immediately after emergence. Adults' life span is very short and last for 3-10 days depending on the season and races. Adults do not feed and incapable of flight. The females are with broad abdomen and males have narrow abdomen. The female lays about 400 eggs copulation with male.

2.3 SEX DIFFERENCES IN LARVA, PUPA AND MOTH

2.3.1 Sex difference in larva

The abdominal segments carry the sexual markings which develop distinctly in the fourth and fifth instars, in the eighth and ninth segments on the ventral side (Fig 2.4).

In the female the sexual markings appear as a pair of milky white spots in each of the eighth and ninth segments. The pair of spots on the eighth segment is known as Ishiwata's fore glands and a pair on the ninth segment is referred as Ishiwata's hind gland. In the male a small milky white spot named Herald's gland appears at the center of the ventral side between the eighth and ninth segments.

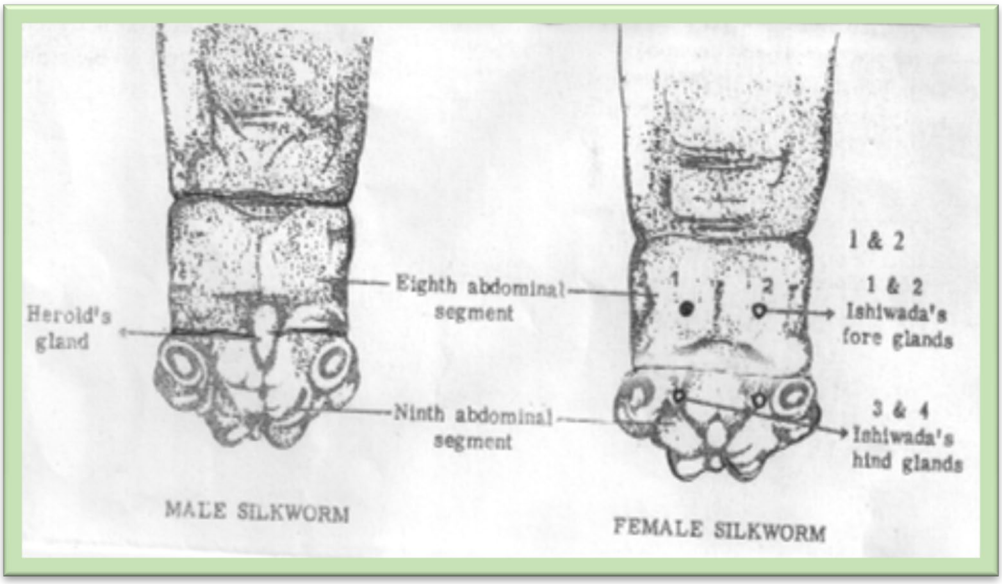


Fig.2.4. Larva sex markings

2.3.2 Sex difference in pupa

These are prominent and very easy to identify the sex of pupa. The female pupae are with broader abdomen while the male pupa with narrow abdomen. The female has a fine longitudinal line (X mark) on the ventral side of eighth abdominal segment. In the male there is a small round spot on ventral side of ninth segment.

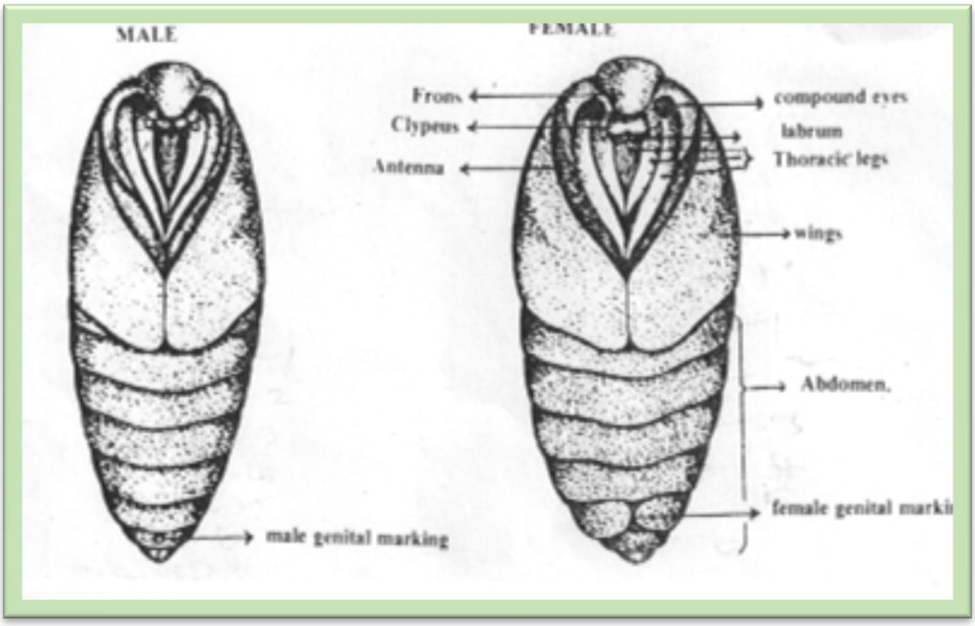


Fig 2.5. Sexual markings of pupa

2.3.3 Sex difference in moth

Morphologically the female and the male can be distinguished in the adult stage. The female has comparatively smaller antennae, its body and the abdomen are fatter, larger and it is generally less active than the male moth. At the caudal end, the male moth has a pair of hooks known as harpes, whereas the female moth has a knob like projection with sensory hairs. These differences help to a large extent in separating the sexes for preparation of hybrid eggs (Fig 2.7).

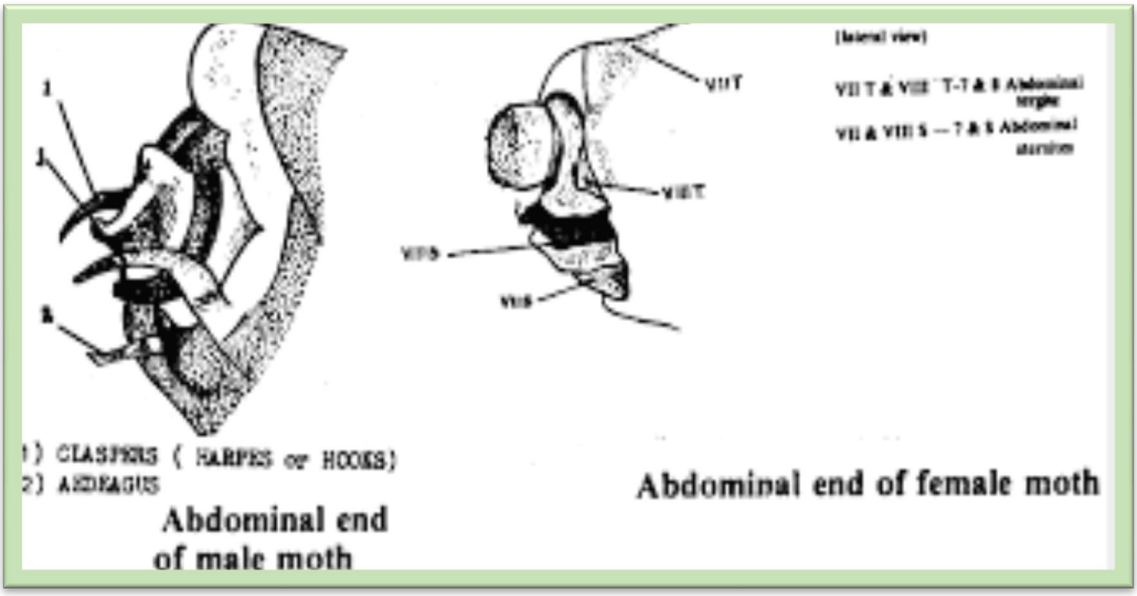


Fig 2.7. Sexual differences at Moth Stage

2.4 Metamorphosis

The silkworm completes metamorphosis by passing through four developmental stages which were explained earlier in this chapter. Such development through different stages which are morphologically different to each other is called holometabolous development. The mature larva spin the cocoon, sheds its skin and metamorphoses into pupa. During pupation, the pro-thoracic gland plays a vital role. In the pupae the brain secretes a hormone which activates the pro-thoracic gland which inturn secretes a hormone inducing the metamorphosis into the moth. The pro-thoracic gland hormone is called moulting hormone or ecdysone.

2.5 SUMMARY

- The silkworm undergoes complete metamorphosis.
- There are four stages in the life cycle of silkworm. They are egg, larva, pupa and adult.
- The eggs are tiny, ovoid, elliptical flat on one side. The flat part is called dimple. The non-hibernating eggs do not change their colour.
- Freshly hatched larvae are called “ants”. The head is large, body covered with bristles.
- The head plates are epicranium, parietals, clypeus and labrum. The 2nd , 4th,5th and 6th segments carry appendages which are modified into antenna, mandibles, maxillae and labium.
- Head bears sense organs and mouth parts.

- The laval thorax has a pair of legs in each segment which are used to hold the leaf while feeding.
- Abdomen has eleven segments. The third-sixth and the last segment has a pair of legs for crawling.
- A caudal horn is present on eighth segment.
- Female larva has Ishiwata on eighth and ninth segment by these two features sexes are identified.
- Pupa is soft and white soon after spinning but becomes hard and brown while tanning of pupal cuticle.
- Compound eyes, antennae, mouth parts are present at the anterior end. Wing pads and limb buds are present.
- Female abdomen is broad and has a longitudinal line on the ventral side of the eighth abdominal segment. In male only a round small spot is on ninth segment.
- Adult moth body is covered by scales. Thorax has two pairs of wings and three pairs of legs.
- The caudal end of female moth has a knob like projection. Male moth has large antennae with narrow abdomen and is very active, the caudal end has harps.
- The silkworm undergoes complete metamorphosis in its life cycle by passing through four different stages *i.e.*,Egg, Larva, Pupa, Adult.
- Life cycle is completed in 6-8 weeks depending upon racial characters and climatic conditions.
- Multivoltine races of tropical areas have shortest life span because of warmer ecological conditions.
- Duration of egg stage depends on diapausing or non-diapausing eggs.
- Non-diapausing eggs normally hatch in 9-12 days.
- Larval period is active feeding stage and important for the rearer as the crop yield depends on various physiological processes of the larva.
- The larval period is 24-28 days consisting of five instars and four moults and grows normally.
- The larvae after reaching the peak growth level they become mature larva.
- The larvae grow to 8,000 to 10,000 times compared to newly hatched worm.
- The first three instars are referred as "young age" or "chawki worms" and fourth and fifth instars as "late age"
- Moulting is shedding of old skin and forming a new one time and duration varies for each moult.
- Moulting is controlled by ecdysone and development of embryo from egg is controlled by juvenile hormone.
- Spinning of cocoon is completed in 48-72 hrs.
- Pupal period lasts for 8-14 days.
- Adult moths copulate immediately after emergence.
- Life span of adult is only 3-10 days.
- Moths do not feed, incapable of flight.
- Female lays about 400 eggs.
- Metamorphosis is holometabolus type.

QUESTIONS

Short Questions

1. How do you identify hibernating and non-hibernating eggs on the basis of egg colour?
2. What do you mean by ant in sericulture?
3. What are the mouth parts of silkworm larva?
4. How do you identify male, female larvae?
5. How do you identify male, female pupae?
6. How do you identify male, female moths?
7. Draw a neat diagram of male and female pupa.
8. Write the characters of silk moth.
9. What do you mean by egg dimple?
10. Mention some of the head plates.
11. What are the life stages of silkworms?
12. What is the difference between the hibernating and no-hibernating eggs?
13. What do you mean by moulting?
14. What is young age and late age?
15. What are the hormones to carry on moulting and instar?
16. Define pupa.
17. Define metamorphosis

Essay questions

1. Write about the morphology of silkworm larvae.
2. Write about the morphology of egg and pupa.
3. Write about the morphological features of pupa and adult.
4. Narrate the morphology of silkworm egg and add a note on sexual markings of larva,pupa and adult
5. Discuss about the life stages of silkworm (or) *Bombyx mori*.
6. Write short notes on

   a. larva b. Pupa

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UNIT 3

PARENTAL RACES

Structure

Learning Objectives

1. Distribution of different races
2. Different parental races
3. Voltinism and moultinism
4. Breed and hybrids of silkworm

3.1. Introduction

There are plenty of silkworm races and strains. Being a domesticated and commercially exploited animal each country is actively engaged in evolving new varieties of *Bombyx mori* by crossbreeding of native and exotic races. A race is formed by combination of all characters heritable to offspring's. The morphological and ecological characters are heritable. The morphological characters are size of egg, colour of egg, colour of newly hatched larvae, form of larvae, size of larvae, colour of larvae, larval markings, shape of cocoons, size of cocoons, colour of cocoons, shape of pupae, size of pupae, colour of pupae, size of moths, markings on wings of moths, colour of moths. The ecological characters are length of larval stage, diapause, moulting, eating behavior, quality of cocoons and filaments, etc. The races are based on native region, voltinism, moulting and cocoon colour. Among these some of the good characters are considered to evolve a hybrid variety. It is necessary to understand about the different parental races from which the present hybrids are evolved for commercial production of cocoons.

The advantages of rearing hybrid silkworms are shorter larval period, low leaf cocoon ratio, mortality is reduced, cocoon weight and the shell weight are high, filament length of fibre is longer, silk filament is thicker, cocoons are more uniform in size and shape.

3.2. Distribution

On the basis of native regions these silkworms are four types. They are Japanese, Chinese, European and Tropical races. European races are native of Europe and Central Asia. Tropical or Indian races are native of India and south East Asia. The univoltine, bivoltine and multivoltine races are found in Japan, China, Europe and India. But some of these varieties like multivoltine is popular in warmer region and reared in India. However, these parental races confined to a particular Geographic region are involved in certain combination to evolve new hybrid varieties. Some of them are maintained (stock) in basic seed forms for future purposes. In Japan alone, more than 2000 genetically identified races are maintained (JOCV, 1981).In India there are about 200 races maintained at different breeding centers (FAO,1981). At present there are separate breeding stations in India for evolving commercial races of multivoltine and bi-voltine varieties.

3.3 Seed Organization

The silkworm seed organization is a vital programme for the success of sericulture industry. To produce good quality seeds there must be a sound seed organization. The silkworm eggs required for commercial rearing should be of high quality and free from disease.

The production and supply of disease free laying's (DFL'S) is highly specialized work at the seed organization. It will be the responsibility of those who are engaged in silkworm seed organization with technical and scientific skills to maintain the basic stock of the races, its multiplication and supply them to the main streams of commercial seed production.

National Silkworm Seed Organization is a separate entity under Central Silk Board (CSB), established in the year 1975 to supplement the efforts of State Governments in supplying high quality Bivoltine and Multivoltine and its cross-breed silkworm seeds to the farmers. It has a mandate to maintain, multiply and supply authorized silkworm stocks, production and supply of quality industrial silkworm seeds and transfer of technologies in the field to improve the productivity and quality of silk.

The seeds maintained at the seed organization can be of Reproductive seeds and Industrial seeds.

Reproductive seeds: It is intended for producing the pure seed cocoons which are required in large numbers for producing commercial hybrid eggs.

Industrial Seeds: these are generally specific hybrids between two or more pure races of silkworms and are reared by the sericulturists for producing cocoons on a commercial scale for reeling purposes.

3.4 Races

As detailed earlier in this chapter there are different races in silkworms. Their classification is based on native regions, the number of hatchings in a year, rearing period, body markings, cocoon colour, egg colour etc.

3.4.1 Based on Place of Origin

There are four types of races. They are as follows.

a) Japanese race.
b) Chinese race.
c) European race and.
d) Tropical or Indian race.

Above said races can be distinguished from one another on the basis of morphological characters of Egg, Larva, Pupa and Adult. Biological characters like duration of lifecycle, diapause, moults, environmental factors, commercial characters like filament length, denier, reelability, mortality, shell ratio etc.

a) Japanese race

It has univoltine and bivoltine silkworms. The eggs are in many colours and are non-hibernating. Many white, rotten eggs are produced in which many eggs die after pigment stage. The larvae are healthy and strong but grow slowly. The markings on the skin of the larvae are normal but sometimes show quail markings. The body is black in colour.

The larvae are yellowish during moult and red in ripe stage. The larvae are slow in eating thus the duration continues for a long period. Silkworms do not identify leaf quality. Cocoons are dumbbell shaped or peanut shaped or spindle shaped with white or straw colour. Many of these are double cocoons. Cocoons are inferior with less fibre length and reeling is generally poor.

b) Chinese race

Chinese eggs are light yellowish in colour. The larvae are white with round body form. They are white during moult and blue in spinning stage. The larvae are robust against high temperature and weak against high humidity. They grow rapidly by feeding actively on mulberry leaves. These are trimoulters, cannot identify the differences in temperature, humidity and air. These larvae are not resistant to Muscardine disease. Cocoon are round or oval or spindle shaped and are white, golden yellow,green,flesh colour,red or even pink in colour.Cocoon filament is long with good reelability.This cocoons are uni,bi,multi-voltine types.

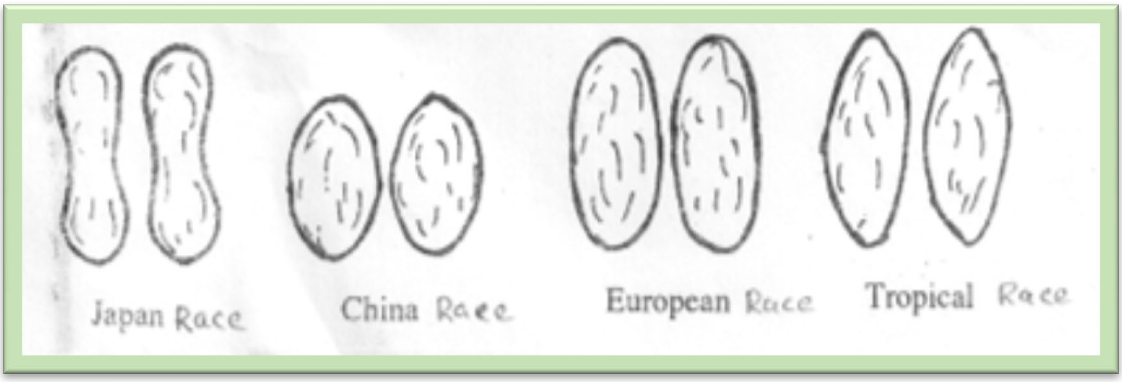

Fig 3.1 Races based on origin

c) European race

Eggs are big, heavy and dark brown in colour. The hatching is irregular. The larvae are long, big with pale normal markings. The larvae are yellowish during moult and red in ripe stage. The larval period is longer and larvae grow fat by feeding actively on mulberry leaves. These are weak against the high temperature and humidity. Pebrine, Muscardine, C-virus diseases are common. Cocoons are long oval, white or flesh or yellow in colour, shell weight is more; fibre is long with good reelability. Double cocoons are less. The sericin counter is more, making easy reelability. These are uni-voltine.

d) Indian race

Eggs are small and are light weight with lustrous shell. The larvae are small, long and are robust against high temperature and humidity. The larval duration is quick except Pure Mysore race. Muscardine disease is common. Cocoons are spindle shaped with green, yellow or white and flossy. Shell weight is less. Cocoon filament is fine but thin. These are polyvoltines.

3.5.1. Voltinism

Voltinism is the ability of silkworm to produce one to several generations in a year.Based on voltinism the silkworms are broadly classified into three types.

a) Univoltine
b) Bivoltine
c) Multi or polyvoltine

a) Univoltine

Silkworms produces one generation in a year are called uni-voltine and lays diapause eggs due to absence of juvenile hormone. They have a long life cycle, Larvae and Cocoons are large. They are very sensitive to environmental conditions. They are unsuitable for summer and autumn. The diapause eggs are reared by artificial breaking. The cocoon filament is of good quality. The shape of cocoon is round and oval which is white and pale yellow in colour.

b) Bivoltine (BV)

They produce two generations in a year. The first generation adult lays non–diapausing egg. The second generation adult developing from non-diapausing egg laid during first generation lays diapause eggs due to absence of juvenile hormone, which is dormant till next spring. The larval duration is short. Larvae are robust and tolerate environmental conditions. The leaf cocoon ratio is less. The quality of the cocoons is inferior to that of Univoltine races. Cocoon weight, shell weight, silk percentage and filament length are lesser than univoltines. Cocoons are dumbbell or oval in shape, white or pale yellow in colour. Example: NB4D2, NB18, KA, NB7 etc.

c) Multivoltine (MV)

They produce more than 5-6 generations in a year. The larval duration is short. The leaf cocoon ratio is high. Cocoons are small in size. The cocoons produce inferior quality silk than uni and bivoltine races. The shell ratio is less. The filament length is short. The filament is fine and clean with little lousiness, but with maximum lustre. The larvae are robust and can tolerate fluctuating environmental conditions and hence best suited for tropical climates. They lay only non-diapausing eggs due to presence of juvenile hormone. Example: Pure Mysore, C.nichi, Hosa Mysore.

3.6. Moultinism

Silkworm larvae cast off its old skin and develop new skin and this process is known as Moultinism**.** Each moulting period lasts for 15-30 hrs. It is a hereditary character. The moulting is a physiological process under the control of ecdysone hormone. Based on number of moults the *Bombyx mori* can be of tri-moulter, tetra-moulter and penta-moulters. In tri-moulters the length of the larval stage is short. The larval body and cocoons are small and the cocoon filament is fine. The tetra-moulters larval duration is medium and produces thin fibre. Most of the commercially reared worms are tetra-moulters with five instars. These worms are reared most widely. In Penta-moulters larval length is long, the body, cocoon and the filament length is large in size.

3.7. Breeds/ hybrids in current use

Earlier attempts to rear bivoltine hybrids resulted only a sporadic success and that too confined only to some seasons of the year, when climatic conditions are not hostile to silkworms The bivoltine breeds developed earlier were with an objective to have higher pupation rate and all the other characters balanced at a moderate level for enabling easy rearing by the farmers. Therefore, limited hybrid vigour could be realized when two such breeds are crossed because both the breeds are on par in almost all the characters. This is one of the reasons for lack of productive bivoltine hybrids in India. Therefore, in CSR&TI, Mysore new breeding programmes were formulated for the development of productive hybrids. This has resulted in the evolution of a series of productive bivoltine breeds (CSR) with high survival and cocoon shell percentage. By systematic evaluation of large number of crosses involving these parents, highly productive hybrids with high quality silk could be identified with cocoon shell percentage of 23-24%; raw silk recovery of 18-19% and 2A-3A grade silk.

Depending upon various factors, different cross-breeding techniques have been employed. The hybrids such as (MV x MV), (PM x C Nichi, PM x C110) mainly for rain fed, low input conditions; (MV x BV) (PM x CSR2, MH1 x CSR2) for average climatic and input conditions and BV x BV (CSR2 x CSR4) for favorable season and/or better input conditions. Research institutes have developed suitable robust BV x BV hybrid combinations (CSR18 x CSR19) for average conditions and double hybrids (FC1) x (FC2) for high input conditions.

Authorization of silkworm hybrids grants recognition to silkworm hybrids for commercial exploitation. The co-ordinated hybrid test is conducted by Central Silk Board (CSB), Bangalore, Government of India, in each year in different seasons at different test centers all over India simultaneously. Based on performance, several hybrids have been authorized at national level and the list of hybrids authorized in recent years is given below:

S.No.	Combination	Hybrid	Recommended for	Season
1	CSR2 × CSR4	BV	South India,Temperate	Spring, Rainy
2	CSR6 ×CSR26 × CSR2 × CSR27	Double hybrid	Throughout India	Spring, Rainy
3	CSR48 × CSR5	BV	South India, Temperate	Spring, Rainy
4	DUN6 × DUN22	BV	North India	Spring, Rainy
5	CSR2A × CSR4A	BV	South India, Temperate	Spring, Rainy
6	BL67 × CSR19	CB	Throughout India	All Seasons
7	MYSORE × CSR2	CB	South India,Temperate	All Seasons
8	N × YB	CB	WB	All Seasons
9	BL67A × CSR101A	CB	South India,Temperate	All Seasons
10	Varuna (BL24 × C.NICHI)	CB	South India,Temperate	All Seasons
11	N × M12(W)	MH	WB	Summer
12	APS105 × APS126	BV	AP, TN, WB	All Seasons
13	APS45 × APS12	BV	TN, JK	All Seasons
14	CSR46 × CSR47	BV	UK , HP, UP, KR, AP, OR, WB, AS	All Seasons
15	DUN17 × DUN18	BV	HP,KR,WB,AS	All Seasons
16	GEN3 × GEN2	BV	AP,TN,WB,AS,JK	All Seasons
17	KSO1 × NP4	BV	KR,HP,JK	All Seasons
18	NK2 × NP4	BV	AS,JK	All Seasons
19	SLD4 × SLD8	BV	KR,AP,TN,WB,AS,JK	All Seasons
20	APDR15 × APDR115	CB	KR,WB	All Seasons
21	APM2 × APDR105	CB	KR,AP,TN,WB	All Seasons
22	APM3 × APS12	CB	KR,WB	All Seasons
23	MCON1 × BCON4	CB	KR,AP,TN,WB,JR	All Seasons
24	MCON4 × BCON4	CB	WB,OR,JR,AS	All Seasons
25	MH1 × CSR2MH1 ×	CB	UP,KR,AP,TN,OR	All Seasons

	CSR2MH1 × CSR2			
26	PM × CSR2(SL)	CB	KR,AP,TN,AS,MN	All Seasons
27	MCON1 × MCON4	MH	KR,AP,TN,WB	All Seasons
28	N × MCON4	MH	AP,TN,WB	All Seasons

Source: CSR&TI, Mysore.

SUMMARY

- There are plenty of silkworm races.
- Hybrids are evolved from different parental races.
- These parental races are distributed in different geographical parts. There are Japanese, Chinese, European and Indian races.
- Races are classified on the basis of native origin, moultinism, voltinism, cocoon colour, larval marking etc.
- The race can be differentiated from one another on the basis of morphological, biological and commercial characters.
- Japanese race lay non-hibernating eggs, larvae grow slowly, black in colour, slow eaters, inferior cocoons.
- Chinese races are robust to high temperature, rapid growth, tri moulters, good reelability, filament is long.
- European race eggs are big, heavy and irregular in hatching, larvae are long, long life, fast growth and weak against high temperature. Cocoons are long with more shell weight with long fibre and good reeling.
- Indian race eggs and larvae are small, robust against temperature and humidity. Cocoons are flossy with less shell weight, filament is fine.
- Silkworms are of three types on the basis of the number of generations produced per year. They are univoltine, bivoltine and multivoltine.
- Moultinism is a racial character based on which the silkworms are classified into three groups. They are Tri-moulters, tetra-moulters and penta-moulters.

QUESTIONS

Short Questions

1. Mention any pure races of silkworm.
2. What are the types of Moultinism?
3. Mention the type of races based on Voltinism.
4. Define Voltinism.
5. Define Moultinism.
6. How many generations' does uni, bi and multi-voltines produce in a year?

Essay Questions

1. Write about parental races based on place of origin.
2. Add a note Voltinism and moultinism.
3. Write in brief about hybrids in current use.

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UNIT 4

GRAINAGE EQUIPMENTS

Structure

Learning Objectives

1. Pre requisites of grainage
2. Grainage model building
3. Different equipment used in grainage
4. Disinfection of grainage building and equipment
5. Uses of different grainage registers

4.1 Introduction

Grainages are the centers for production of large scale quantities of disease free layings of silkworm. Grainages produce pure and hybrid seed. These centers are more popular as commercial egg production centers because they have a direct link with seed rearers. These centers encourage progressive farmers and seed rearers to produce seeds commercially. Farmers always intense to produce good quality cocoons, hence the farmer look forward to the Grainage for the supply of high vigor disease free commercial seeds. These seeds produce cocoons with rich silk content and high yield.

The Grainage should have proper facilities, good environmental conditions and well spacious rooms, without water stagnation around the Grainage building and should be away from factories and pesticide industries. A Grainage must be established where sericulture is popular among the villages. It can also help the farmers technically. These Grainage centers conduct training program for the unemployed youth to create awareness on commercial rearing

4.2 Prerequisites of Grainage:

There are important prerequisites for running a Grainage operation. They are (1) Building location (2) Structure of Grainage building (3) Grainage equipments (4) Technical staff.

4.2.1 Building Location

The location of the Grainage should be in commercial cocoon producing area to fulfill the needs of commercial rearers. If the Grainages are located away from the seed areas, transport of seed cocoons and eggs is unsafe especially in summer, the high temperature leads to pupal death, melting of cocoons, irregular hatching, more number of dead eggs and poor moth emergence which affect the complete rearing activity. Hence Grainages should be located in commercial cocoon producing areas for easy transport of seed cocoons and also to transport layings to the rearing centres. The surrounding of the Grainage must be free from polluted air since it is unsuitable for egg production.

4.2.2 Labour

Processing of egg production requires large number of laborers. Since the span of seed cocoons is very short and the large numbers of cocoons are utilized for egg production, more than the technical staff requirement the unskilled labour is utmost essential.

4.2.3 Seed Rearers

The Grainage should have a proper number of rearing centers for easy transport and for getting technical support and supervision.

4.3 Grainage Model Building

The egg production and processing should be carried out with lot of care and necessary techniques. It requires specific environment to carry out the Grainage activity. Hence separate convenient building is required. Each stage of Grainage activities is confined to a particular room with suitable environment. Light, temperature and humidity plays a major role in various activities. Some rooms require good ventilation and some rooms require darkness. For preservation of seed cocoons long and spacious room is required (Fig 4.1)

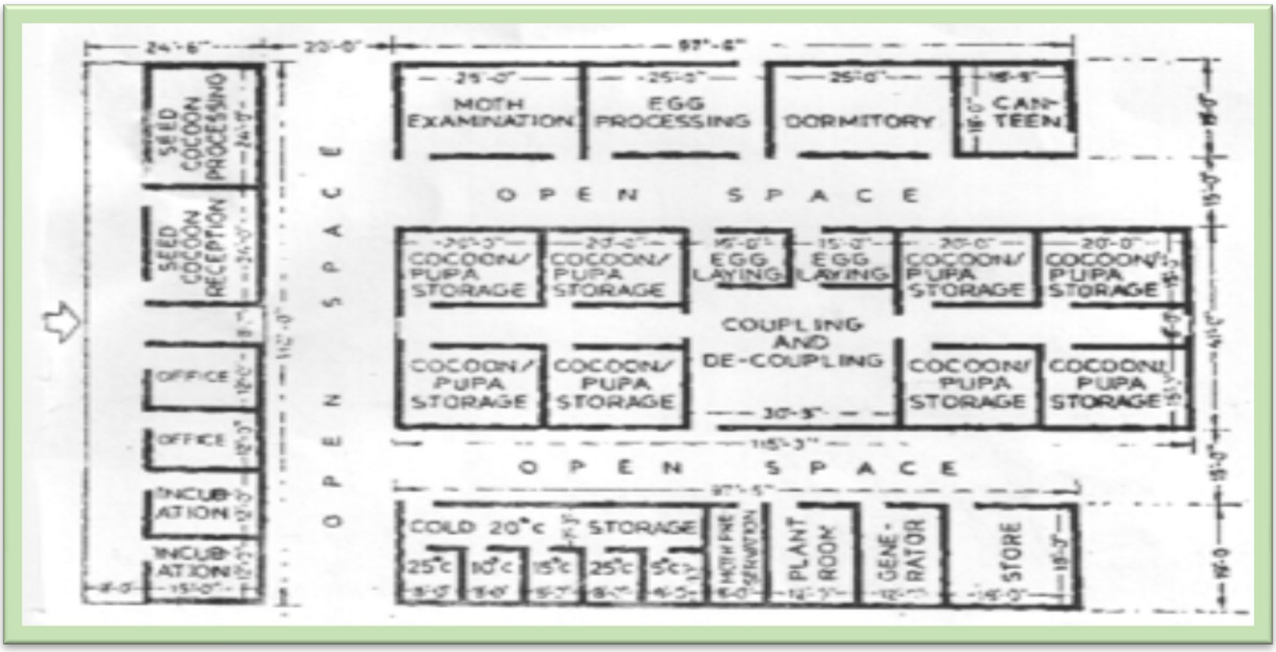


Fig 4.1 Ground plan of model grainage building

4.3.1 Well Planned Grainage building: Well planned Grainage building must possess the following components.

1. Seed cocoon reception and processing rooms.

2. Seed cocoon/Pupae preservation rooms.

3. Coupling and decoupling room.

4. Egg laying chambers.

5. Moth examination lab.

6. Egg processing room.

7. Incubation chambers.

8. Cold storage room.

9. Office and dormitory.

10. General and pierced cocoon stores.

The size of the grainage building varies with the target of egg production. A model grainage for industrial seed production for a capacity of 25 lakh dfls per annum is shown in the above diagram.

The industrial grainage should not be located in seed areas. In temperate and sub-tropical regions they should be constructed in a north-south direction to get maximum sunlight to warm up the rooms. In tropical regions they should be oriented in an east-west direction to avoid the effects of direct sunlight and to achieve cooler temperature. The Grainage building must be in such a way that the rooms for step by step processing are located adjacent to each other to avoid movement of labourers and staff and confusion in preparation of layings. Moth examination room should be away to avoid contamination. oviposition room should be nearer to cocoon preservation rooms. The cocoon preservation rooms, Pairing rooms, ovi-position rooms must be provided with facilities to maintain temperature, humidity and provide darkness and light when needed.

Moth examination rooms are provided with wider windows and artificial light for examination. Washing and facilities for acid treatment are compulsory in egg washing room. Cold storage room must be near to egg laying room for easy maintenance of optimum temperature in ovi position rooms.

4.3.2 Technical Staff

The Grainage activity has three components i.e., supply of parent seed cocoons; processing of cocoons, moth examination and disposal of seed. All these activities are carried out by group of technical staff. The grainage of 15 lakh capacity should have 16 technical staff to carry on all the processes of egg production.

4.4 Grainage Equipment and Uses

The grainage equipments are designed for a specific function. These equipments are made in such a way to transport and handle easily. Equipment is used to control disease incidence to sterilize, to check the attack of ants, to check light and to keep moths undisturbed. The Grainage equipment and their uses are as follows.

4.4.1 Cocoon Preservation Stand

Cocoon preservation stand are made of wood or bamboo or iron. It is easy to move them from place to place. This rack measures 228.6 cm height, 144.8 cm length and 61 cm breadth and should have 10-12 shelves with a space of 20 cm between each shelf. The seed cocoon preservation trays are arranged on the shelves and each stand can accommodate 10 trays. It is used for preservation of seed cocoons on the shelves (Fig4.2).

4.4.2 Cocoon Preservation Trays:

Grainage trays are portable receptacles for keeping seed cocoons, paired moths and egg laying moths. Trays are of two types such as the following

a. Round tray b. Rectangular tray

a. Round tray:

It is made of bamboo and easy to handle. It is used for preservation of seed cocoons. Each tray is of 137.2 diameter in size, depth 6.5 cm (Fig 4.2).

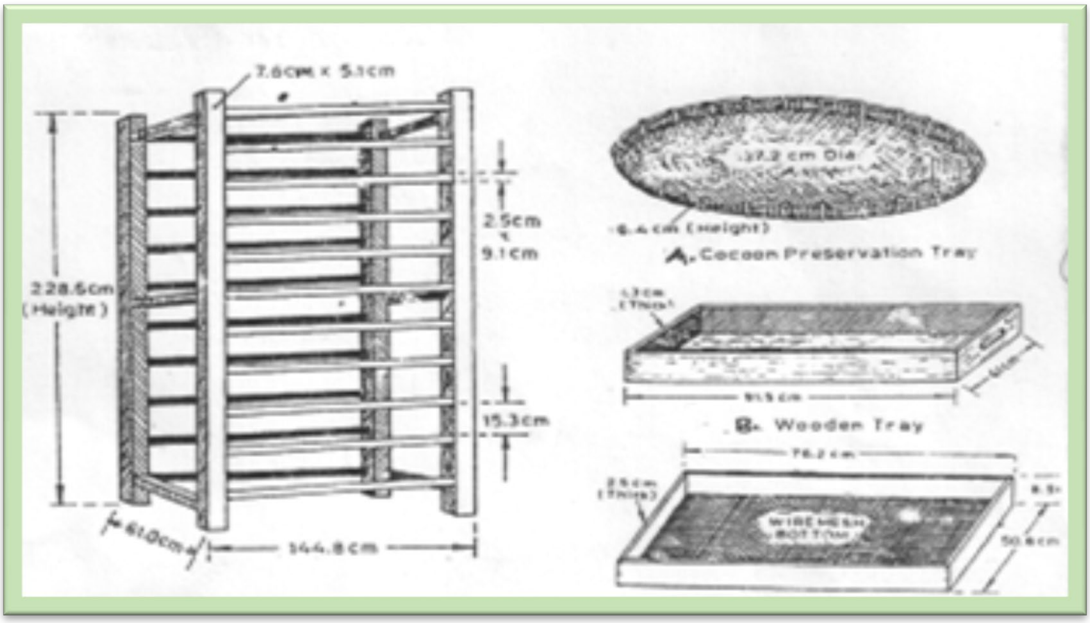


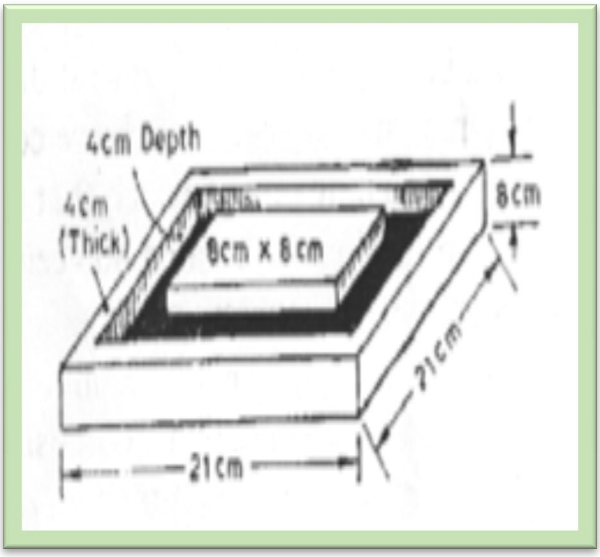
Fig. 4.2 Grainage stand and trays

b. Rectangular trays or Wooden trays

It is made of wood, ply wood or wire mesh bottom. It is used in Grainage for pairing and oviposition of moths. It measures 91.5cm length and 61 cm breadth (Fig 4.2).

4.4.3 Ant Well

It is made of concrete or stone blocks, 21 cm square and 8 cm high with a deep groove of 4 cm running all round the top. The leg of Grainage stand rest on the centre of the block and water is poured into the groove to stop crawling of ants on to cocoon preservation trays. Each stand leg must rest in a well. Antwells are used to control the attack of ants. Ants cause lot of damage to cocoons and moths (Fig 4.3).



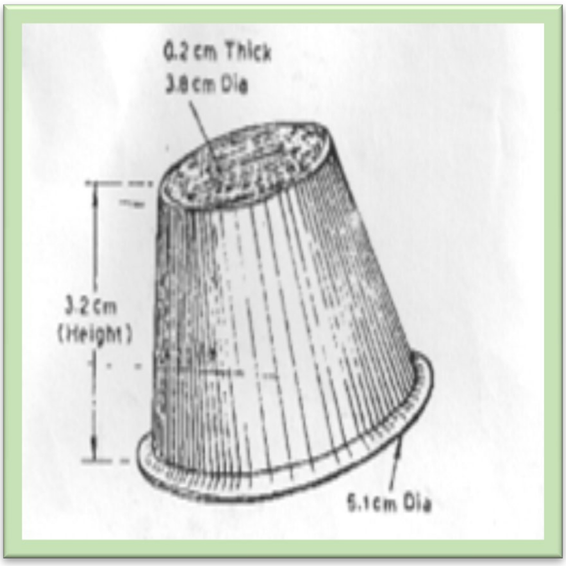


Fig 4.3 Ant well

Fig 4.4 Cellule

4.4.4 Cellule

It is made of plastic which is black in colour measuring 3.2 cm in height and 5.1 cm in diameter. The copulated females are kept on an egg sheet and are covered with a cellule. It provides semi-dark condition around the paired moths and ovipositing female moths. It increases the fertility and egg laying capacity (Fig 4.4).

4.4.5 Moth Crushing Set

It is made of porcelain having 10 mortars and 10 pestles. It is used for crushing the larva, pupa and moths to prepare smears. The supernatant liquid after centrifuge is examined under the microscope for identification of pebrine spores. Diseased moth eggs are discarded before processing (Fig 4.4.5).

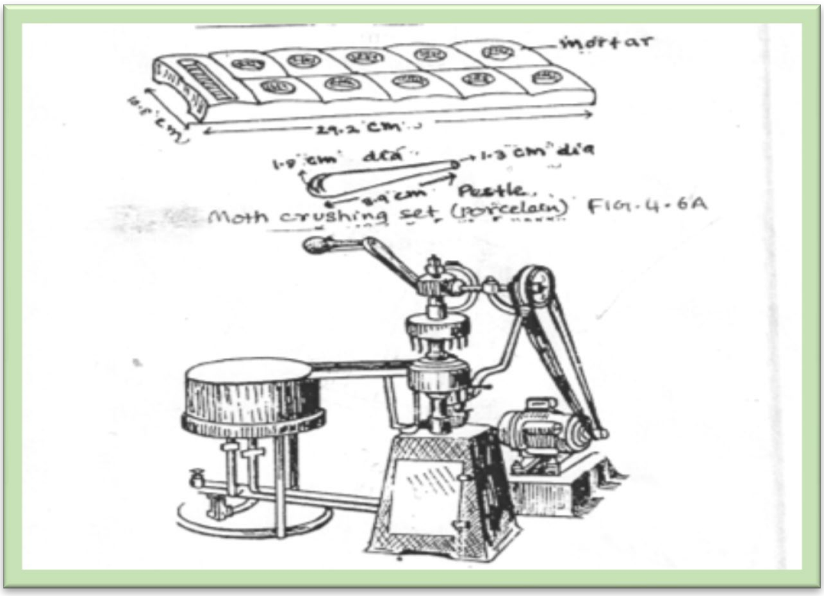


Fig 4.5 Moth crushing set

4.4.6 Microscope

Compound microscope is used for detecting the pebrine spores during pupal examination and mother moth examination ovi-position and pebrine spores are detected at 600x magnification (Fig 4.6).

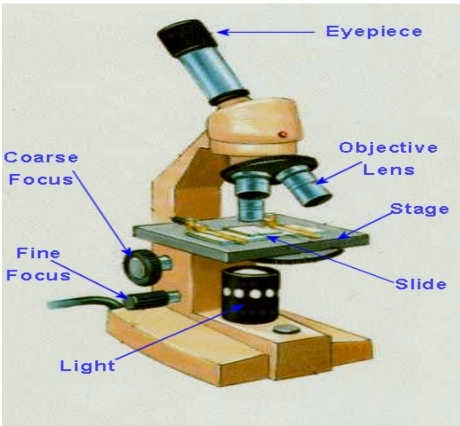


Fig 4.6 Compound microscope

4.4.7 Wet and Dry bulb Thermometer

It is used to measure the room temperature and relative humidity in the Grainage (Fig 4.8).

Fig 4.7 Wet and Dry Bulb Thermometer

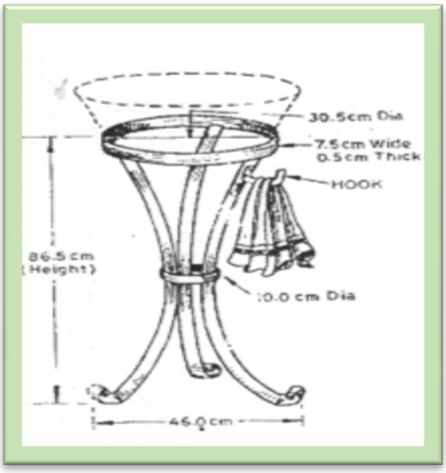
Fig 4.8 Dial Hygrometer

4.4.8 Dial Hygrometer

It is used to measure room humidity directly and humidity in rearing tray or bed (Fig 4.8)

4.4.9 Wash Basin or Basin Stand

It is a tripod stand with a height of 86.5 cm to hold a basin (30.5 cm dia). The basin is filled with 2 % formalin. This liquid is to wash and sterilize hands while entering into the room. It is kept nearer to cocoon, moth preservation room and egg laying room (Fig 4.9).



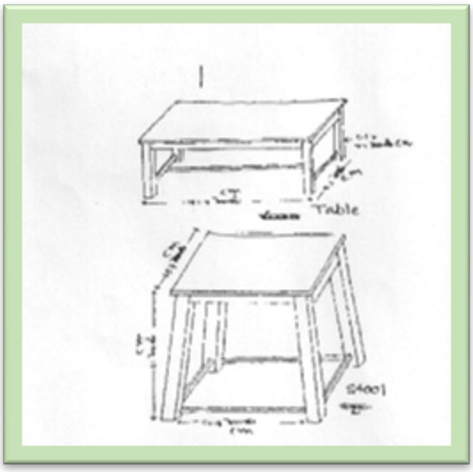


Fig 4.9 Wash basin and stand

Fig 4 10 Moth testing table and stool

4.4.10Acid Treatment Bath

This equipment is used for treating the univoltine and bivoltine layings to break hibernation and enables them to hatch as usual.

4.4.11 Crates

Crates are used for preserving the male moths after emergence.

4.4.12 Refrigerator

Refrigerator is used for synchronization of moths and also to preserve male moths which can be used for second pairing.

4.4.13 Incubator

Incubators are used to incubate the silkworm eggs at 23-25°C temperature and 80-85% relative humidity for uniform development of the embryo.

4.4.14 Sprayer

It is used for disinfecting the Grainage building and equipments.

4.4.15 Mouth Mask

The silkworms have plenty of scales on body and wings. These scales are spread in the moth emergence room during their emergence. Thus mask is used to prevent inhaling of scales, dust and formalin fumes by workers.

4.4.16 Deflossing Machine

Deflossing machine is used to defloss the cocoon before moth emergence. It is operated by pressing the pedal.

4.4.17 Cocoon Cutting Machine (CCM)

It is used to cut the cocoon and separate the pupae which is one of the important activities in preparation of hybrid layings.

4.4.18 Formalin Mat (Foot Cleaning Tray)

A gunny bag or cloth piece is spread in a iron sheet tray having 2 % formalin or any other disinfectant and kept in front of the door. While entering into the room one should keep the foot in the tray for disinfection.

4.4.19 Moth Testing Table and Stool

These are used to keep microscope during moth examination. The table is to keep moth crushing set, slide box, cover glass packet, water or KOH and observation note book. The stool is used for sitting during moth examination (Fig 4.10).

4.4.20 Other Equipment

Other equipments like air cooler, slide box, cover glasses, electric heater, egg sheets, loose egg boxes, hydrometer, clock are also required for grainage.

4.5 Disinfection

Destruction of diseased germs in Grainage building and equipments is called disinfection.

4.5.1 Types of Disinfectants

The basic chemicals used for disinfection are

1. Chlorine compounds like chloramines.
2. Iodine as iodophors.
3. Phenol derivatives like cresol, hexa chlorophene.
4. Formaldehyde.
5. Bleaching powder.
6. Sodium hypochloride.
7. Lime powder

Among all chlorine dioxide, formaldehyde, bleaching powder are most popular disinfectants used by silkworm rearers. These are used as spray, dusting and for fumigation.

4.6 Grainage registers / records

It is essential that accurate data of seed production are maintained in the Grainage. This will help in efficient management, control of quality. The following are the types of records to be maintained in Grainage.

A. Seed Cocoon Register

The register should contain information about the parental race, yield, defective cocoon percentage, seed rearer details, details of seed cocoon seller, cocoon purchase rate, weight of cocoons purchased and their cocoon quality details.

B. Moth Emergence Register

The register should contain details of moth emergence such as number of moths obtained each day, number of moths kept for pairing, percentage of emergence, number of moths kept for egg laying under each combination are recorded. This will help in forecasting the production and planning for hibernation. These data are to be maintained separately for different batches.

C. Moth Examination Register

Maintenance of this record is important, as it provides information on the number of moths examined, type of examination conducted, presence of pebrine, if present, percentage of infection, whether the batch is to be rejected.

D. Egg Production Register

Information pertaining to the quality and quantity of eggs laid, unfertilized eggs rejected, quality fit for distribution, type of egg (hibernated and non-hibernated) are maintained.

E. Hibernation and Refrigeration Register

In this register contains details of refrigeration, hibernation, date of release, temperature in cold storage and number of moths kept in refrigerator.

4.7 Summary

- Grainages are the centers for production of large scale quantities of disease free layings.
- Location of Grainage must be near to commercial cocoon producing areas for easy transport of eggs as well as seed cocoons.
- Grainage location must be free from polluted air.
- Procurement of laborer is an important prerequisite.
- Identification of seed rearers is carried by technical persons.
- Egg production and processing is carried out with lot of care and technique.

- A separate, convenient building to carry outon all activities pertaining to egg production is required.
- The components of a Grainage building are to be kept in mind while construction.
- In temperature and sub-tropical regions buildings should be constructed in a north-south direction.
- A Grainage of 15 lakh egg production capacity should have 16 technical staff to carry on all the processes.
- Grainage equipments are designed for a specific function.
- Cocoon preservation rack is used to keep trays containing cocoons, pupae and moths.
- Ant wells, enamel plate, kerosene dipped cloth, are used to prevent ants attack.
- Washbasin, foot cleaning tray are used for disinfection of hands and foot before entering into Grainage room.
- Moth crushing set is used to crush the moth and then to observe under microscope to examine for pebrine infection.
- Eggs with pebrine disease are discarded.
- Hygrometer, thermometer used to find out temperature and relative humidity.
- Cellule is to cover coupling, egg laying moths.
- Other equipments like deflossing machine, cocoon cutting machine, sprayer, crates, refrigerator, incubator, mask, air cooler, egg sheets and loose egg boxes are required.
- Acid treatment bath is to treat the bi-voltine and uni-voltine eggs to stop diapausing.
- The common disinfectants used in sericulture are formalin solution, lime powder, bleaching powder applied as spray, dust and for fumigation.

Questions

I. Short Questions

1. Define Grainage.
2. What is the best location for establishing a Grainage?
3. What are the components of the well planned Grainage building?
4. What is the best orientation for Grainage?
5. How many technical staff is required in 15 lakh Grainage?
6. Mention some Grainage equipment.
7. Draw a neat diagram of ant well and wooden tray.
8. What is the use of Ant well?
9. Draw a neat diagram of cellule and bamboo tray.
10. What is the use of microscope?
11. Draw a neat diagram of moth crushing set.
12. How do you measure room humidity?
13. What is the use of acid treatment bath?
14. What is the use of face mask?
15. What is the importance of formalin mat?
16. What are the uses of washbasin?
17. What are the uses of cellule?

18. What is the use of incubator in Grainage?
19. Mention some disinfectants used in Grainage.
20. What are the disinfectants used in Grainage?

II. Essay Questions

1. What are the prerequisites for Grainage operations?
2. Discuss about the components of Grainage building.
3. List out the Grainage equipments and its uses.
4. Write about the equipment used for pebrine detection.
5. What are the records maintained in grainage?
6.. Write short notes on
   a. Trays b. Moth crushing set c. Ant well
7. Write short notes on
   a. disinfectants b. cellule c. Basin Stand.
8. Write short notes on
   a. Hibernation register b. Incubator c. Formalin mat

Ψ

UNIT 5

GRAINAGE OPERATIONS

Structure

5.1. Introduction

5.2. Selection of seed races

5.3. Procurement of seed cocoons

5.4. Sex separation

5.5. Coupling and de-coupling

5.6. Oviposition

5.7. Summary

Learning Objectives

- Selection of seed races
- Procurement of seed cocoons, preservation and moth emergence
- Sex separation
- Coupling and de-coupling of moths
- Oviposition

5.1 Introduction

The climatic conditions of our country vary in different parts of the region, so the farmers grow different varieties of silkworms, which produce cocoons yielding poor silk. Whereas the foreign varieties or exotic races like Chinese, Japanese produce superior quality of cocoons but unable to rear in India because of climatic conditions. The local varieties (multivoltine) are crossed with the foreign varieties (Univoltine and bivoltine) to produce hybrid varieties. Apart from that disease free layings are must to produce quality of silk. Thus egg production is a technical job carried out systematically under trained technicians and laborers to achieve good results.

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. Hence it is necessary to conduct these grainage processes with utmost care and technique. All these processes must be recorded for future use to improve the skills to identify the lapses to minimize the expenditure to increase the production of disease free layings (Dfls), to know the pebrine disease and to confirm improved varieties etc.

5.2 Selection of Seed Races

The silkworm eggs required for commercial rearing should be of high quality and free from diseases. To produce good quality seed there must be a good seed organization. Considering the importance of quality seed, the Sericulture countries have established a network of institutions for egg production and also to impart training to the staff working in Grainages. Silkworm seed is divided into two types *i.e.*, **a**. Reproductive seed **b**. Industrial seed.

5.2. a. Reproductive Seeds

These are used for producing the seed cocoons (parents of seed cocoons) which are required in large numbers for producing commercial seed. The purposes of these are for maintaining the racial purity which is difficult to rear, so special care must be taken by technical staff. The selling price of these is 30-50 % more than reeling cocoons (Commercial cocoons). Reproductive seeds are often multiplied in number in a series of breeding centers called breeding stations (P4 or P3, P2, and P1). In three or four stages in order to ensure that the racial characters are not diluted during the multiplication stages.

5.2.2 Industrial or Commercial Seeds

There are specific hybrids between two or more pure lines of silkworm races and are reared by the sericulturists for producing cocoons on a commercial scale for reeling purpose. These are hybrid seeds, produced in special organizations called Grainages.

There are three aspects in seed production. They are

1. Breeder’s stock.
2. Basic seed multiplication.
3. Industrial seed production.

The race breeding stations are maintained by the government. These centers multiply Great Grand Parents or the Grandparents (P4 or P3) of commercial Grainage seeds. These centers contain all pure races and are aimed to maintain purity of the races. These centers supply the basic or initial material for multiplication to the breeding centers.

Normally the seeds of multivoltine races (Pure or CB) are multiplied in three-tier system (P3, P2, P1) while exotic pure breed races of bivoltine, rare multivoltine have four-tier system (P_4). The above said stations (P_3 or P_4) supply parental seed cocoons for rearing at foundation stock seeds (P_2 Station). A multiplication of pure breed races are done by seed cocoon rearers who in turn produce seed cocoons. These seed cocoons are brought to the industrial seed producing Grainages (P_1) to produce the hybrid seeds which are also called foundation hybrids.

Generally Grainages where the layings of the parental races are produced and managed by government agencies whereas the industrial seed grainages may be private or government owned. These grainages are aimed to produce reproductive and industrial seed.

5.2.3 Selection of Seed Rearer

The rearing of seed cocoons requires technical skill. Seed Cocoons must be healthy, hygienic and confirmed to the original traits. The seed rearer is to be selected on the following criteria.

- The rearer should have a scientific knowledge of the silkworm rearing and grainage operation. He should have an interest in silkworm seed production.
- Mulberry garden should be cultivated by adopting new package of practices.
- The rearing house should be located in an area suitable for seed rearing with optimum rearing conditions. It should be free from germs of silkworm diseases.

5.3 Procurement of seed cocoons

Seed cocoons are those which are produced under ideal climatic condition, free from diseases, exclusively for the purpose of reproduction, seed cocoons should confirm to the racial characteristics. In practice these seed cocoons are raised in seed areas.

As the quality of seed cocoons determines the quality and productivity of seeds, it is very important that the cocoons procured for seed preparation should be of high standard. Keeping this in view, standards are fixed in respective of different races and seasons. The important norms for procuring the seed cocoons are as follows.

1. Purchase cocoons which have been closely watched by the extension staff and health certificate affixed on inspection card.
2. Gut examination of the pupae must be conducted before purchase.

3. The seed crop should be free from diseases especially pebrine.

4. Cocoons showing even a slight incidence of pebrine must be rejected.

5. The seed crop should have been reared under ideal conditions and fed with nutritious mulberry leaves.

6. The seed crop should have a good survival rate.

7. The seed crop should have a high pupation rate, but do not purchase cocoons which are with very heavy pupal weight that might lead to melting.

8. The cocoons should have good cocoon weight.

9. Cocoons which are not confirming to the characters of the race should not be purchased.

10. Crops showing an average yield of cocoons and above as fixed by the norms should only be purchased.

11. Rates are fixed as per the standards.

12. Purchase officer must certify for the quality of the cocoons and its disease freeness.

13. Details of rearer, quality and quantity of cocoons, race, spinning date, cost, total amount paid, name of the market are recorded and sent to the Grainage along with cocoons.

5.3.1 Price Fixation

There are certain norms for fixing the price of the cocoons which are periodically revised by the government in favor of the seed cocoon growers. On the day of marketing to the Grainage the yield of cocoons must not be less than 30 kg per 100 dfls for bivoltines and 20 kg per 100 dfls for multivoltine. Number of cocoons per kg in bivoltine must not be less than 550 to 700 and in multivoltine must not be less than 850 to 1100. Timely, these norms vary accordingly as per the fixation made by the Government.

5.3.2 Process of price fixation

a. Standard Cocoon number (Bivoltine) – 650 / kg , multivoltine- 1000/kg

b. Standard Rate : It is fixed by the government from time to time.

c. Rate fixed per kg of cocoons brought by the farmer

$$\textbf{Cost of the cocoons} = \frac{\text{Standard Rate x No. of standard cocoons/kg}}{\text{No. of cocoons/kg of the farmer}}$$

Model Problem I: A farmer has brought 40 kg of bi-voltine cocoons which are 620 in number per kg. The standard rate is Rs. 125/kg. Calculate the cost of cocoons per kg and calculate total amount to be paid to the farmer.

Standard cocoons = 650 per kg.
Standard Rate per kg = Rs. 125
Number of cocoons per kg of the farmer = 620

$$\textbf{Cost of the cocoons} = \frac{\text{Standard Rate x No. of standard cocoons/kg}}{\text{No. of cocoons/kg of the farmer.}}$$

$$= \frac{125 \times 650}{620} = \frac{81250}{620} = \text{Rs. } 131.04$$

Cost of one kg = Rs 131.00

Total quantity of the cocoons brought by the farmer = 40 kg

Total amount to be paid to the farmer = 131 x 40 kg = Rs. 5240.

Model Problem – II

A seed rearer procured 55 kg of multivoltine cocoons and 900 in number per kg. The standard rate is Rs. 100/kg. Calculate the cost of cocoons per kg and calculate total amount to be paid to the farmer.

Standard cocoons = 1000 per kg.
Standard Rate per kg = Rs. 100
Number of cocoons per kg of the farmer = 900

$$\textbf{Cost of the cocoons} = \frac{\text{Standard Rate x Number of standard cocoons/kg}}{\text{No. of cocoons / kg of the farmer.}}$$

$$= \frac{100 \times 1000}{900} = \frac{100000}{900}$$

The total amount to be paid to farmer is =111 x 55 = Rs. 6105.

5.3.3 Transportation and preservation of Seed Cocoons

It means carrying seed cocoon safely from producing centers to egg processing centers. Safe transportation is necessary not to affect pupae and cocoons which hamper the moth emergence. The seed cocoons are harvested on the 5th or 6th day after spinning. This stage is suitable for transportation. If the pupa has turned dark brown in colour and if it is hard to touch then the seed cocoons are fit for transportation. The best time for transportation of seed cocoons is the cooler hours of the day *i.e.*, early morning or late evening. During hot days, if the cocoons are transported it will damage the pupae due to the heat and such cocoons emerge weak moths which either die or lay poor eggs. Laying and hatching of such moths laid eggs will be irregular.

Seed cocoons should be loosely packed in the containers (cloth bags, Bamboo conical basket, and plastic perforated bins)So as to allow sufficient space for aeration. Each container is perforated and the containers are placed horizontally one upon the other in rows.

5.3.4 Selection of Seed Cocoons

As soon as the cocoons arrive at the grainage, they are checked for their quality and quantity as per the details received from the cocoon market. Thus a preliminary examination is conducted to make sure that the seed cocoons are free from pebrine. From each batch of cocoons from the rearer about 20 pupae are collected and gut examination is conducted for pebrine disease.

5.3.5 Preliminary Examination

It is of two types such as pupal gut examination and forced eclosion test (emergence). As the pebrine spores tend to concentrate in the gut region, the pupal gut is extracted and examined. When the infection is at initial stage, identification becomes difficult. To overcome these, the cocoons are subjected to high temperature (30-32°C) for early eclosion. The emerged moths (after 2-3 days) examined for pebrine spores. The identification of pebrine is crucial, thus the cocoons are subjected to both type of examination.

In each test examine 2-3 smears and 8-10 fields carefully. The pebrine spores, if present appear as an oval shinning body under 600 magnifications of the microscope. If pebrine is noticed, further processing of cocoons is stopped and they are immediately disposed by burning.

5.3.6 Processing of Seed Cocoons

It is also called as cocoon sorting where good and defective cocoons are separated from the cocoonslots. The seed cocoons declared as free from pebrine disease are preserved for egg production. The cocoons which are deformed, flimsy, stained, double, flossy, thin, pointed, malformed and dead are rejected. Batches of cocoons showing higher percentage of melting are sent to reeling centers. Only good cocoons of quality confirming to the breeds are selected and preserved. De-flossing of cocoons is done to facilitate easy eclosion of moth. Defective cocoons are either stifled or sent to cocoon market. It is unhealthy to keep such cocoons in the grainage.

5.3.7 Preservation of Seed Cocoons/Pupae

Good cocoons are arranged in a single layer in bamboo trays. Each tray can hold 1000-1200 multivoltine cocoons or 800-900 bivoltine cocoons. Overcrowding should be avoided, which leads to pupal mortality. The cocoon trays are arranged on stands.

Temperature and humidity play vital role in cocoon and pupa preservation. The proper temperature range of 23-26°C and 70-80 % humidity are maintained during preservation. The uniform eclosion of moths depends on the intensity and duration of light. Cocoons should be exposed to diffused light during the day and darkness during the night. The higher the temperature the lower will be the eclosion rate. At a temperature 30°C and above, the eclosion rate get reduced to the minimum and infertility sets in the male moth. The moths become weak, not able to copulate and the eggs laid by them do not hatch. At lower temperature(20°C),the eclosion is delayed and the egg laying period is extended and becomes irregular, the size of the egg is reduced and laying percentage decreases while unfertilized eggs increases. Similar phenomenon is also noticed with the humidity.

Cocoons are cut on one side or both sides to increase the percentage of moth emergence and they are stored in the round bamboo tray. In some Grainages pupae are taken out from the cocoon and male, female pupae are stored separately in wooden rectangular trays containing a corrugated paper or saw dust or powdered paddy husk. Over the thin layer of cocoons or pupae perforated paper is placed through which emerged moths make their way out. This facilitates easy picking of moths for coupling.

5.4 Sex Separation

For preparation of hybrid eggs, the male and female moths of two different races are crossed (bivoltine, multivoltine races).When the moths emerge, the male and female moths of the same race copulate, this produces eggs of a pure race. To prevent this, it is necessary to separate the sexes before emergence so males and females are kept in separate trays. The sex separation can be done at larval stage, pupal stage and moth stage. Now a days, sex-limited races are also available, in which based on cocoon colour males and females are separated at pupal stage itself. In these races all female worms spin yellow cocoons and males spin white cocoons. By selecting required sex remaining cocoons can be sent for reeling market. This helps in easy sex separation, avoid selfing, saves labour and cost of egg production. But commercialization of such breeds is yet to be popularized or brought to the practical usage.

Larval Stage

In larval stage the abdominal segments carry the sexual markings, which develop in the 4^{th} and 5^{th} instars, in the 8^{th} and 9^{th} segments on the ventral side of the larva. In Female larva a pair of milky white spots present in 8^{th} and 9^{th} abdominal segments (**Ishiwata's glands**). In the male a small milky white spot (**Herold's gland**) appear at the centre of the ventral side between the 8^{th} and 9^{th} abdominal segments. Sex- limited races will have separate markings for male and females.

Pupal Stage

When compared to larval stage it is easy to determine the sex in the pupal stage. Female pupae are larger in size with a broad abdomen and an 'x' mark can be seen on the ventral side of the 8^{th} abdominal segment. Whereas the males are smaller in size having a narrow and pointed abdomen with a small dot like mark on the ventral side near the top demarcation line of the 9^{th} abdominal segment.

Moth Stage

Female moths are inactive, larger in size and possess narrow antennae without bristles. The abdomen is bloated due to the presence of eggs. At the posterior end of the abdomen there is a protractile knob like ovipositor. Male moths are distinct by their smaller size, narrow abdomen and broader antennae with bristles known as Pectinate Antenna. Male moths are very active and are seen fluttering their wings in search of females. At the posterior end of the abdomen there is a pair of hooks like structures called Harps or Claspers.

5.5. Synchronization of Moths

Moths of different races are made to emerge simultaneously on the same day and at the same time, so that the male and female moths are readily available for Hybridization. This phenomenon is referred as **"Synchronization".** The synchronization process is to be planned from the brushing time of the parent races or cold preserved based on emergence time.

To prepare hybrid eggs, some adjustments are made so that the moths of different races emerge at the same time. This is done by selecting cocoons which spin on different dates, depending on the number of days required for emergence. If it cannot be adjusted for any reasons, the cocoons of the early emerging races have to be refrigerated at 5- 10°C for 2-4 days. The refrigeration should be done preferably on the 7th or 8th day after spinning. The cocoons which are about to emerge should not be refrigerated. If refrigeration is not done in the cocoon stage, synchronization can be achieved by refrigeration of moths which emerge earlier. Male moths can be refrigerated at 5°C for 7 days. Female moths can be refrigerated at 5°C for 2 - 3 days. However, refrigeration of female moths is not advisable as it increases the percentage of unfertilized eggs and poor layings.

Precautions

1. Refrigeration should be restricted to any one stage.
2. Significant humidity should be maintained during cold storage.
3. In General, cold storage of either sex of multivoltine is discouraged as it affects egg number.

5.6. Moth Emergence

The silkworm after spinning the cocoon, lodges inside the cocoon and transforms into a pupa. The pupa later transforms into a moth and comes out of the cocoon. The process of moth coming out of the cocoon is called “Moth Emergence” (Fig 5.1).

Fig 5.1 Emergence of silk moth

Generally moths emerge out of the cocoon after 9-14 days of spinning. But the pupal age varies according to races and seasons. Multivoltine races emerge earlier than other races. The expected time of moth emergence can be predicted by observing the pupal and cocoon characters. A day before becoming moths, the pupae appear soft, dark in colour with loose pupal skin, prominent eye formation, wing parts, appendages appear. A day before emergence, a distinct sound is heard in the seed cocoon room, due to transformation of pupae into moths which are trying to rupture the pupal skin to come out.

It requires a specific environmental condition for cocoon or pupae before emergence of moths. These are two be kept in total darkness. On the expected day of emergence, bright lights are illuminated in the early hours of morning at 4 - 6 a.m. At the time of emergence temperature of about 25°C with humidity 70 - 80 % should be maintained. Moths start emerging from 6 - 8 a.m. which are picked and kept in a tray for urination. Then healthy moths are are taken for coupling or for preservation. The emergence of moths decreases as the day light intensity increases. Moths do not emerge after 8.30 a.m. Light is provided only in the subsequent days of emergence. Thus room is once again made dark and light is provided only in the subsequent days of emergence. The emergence of moths lasts for 3-4 days only. Sometimes due to mistakes in sex separation moths of other sex mix and emerged moths mate. Such pairs are rejected.

While emergence the moth ruptures the pupal skin and secretes an alkaline juice on one end of the cocoon and makes it wet. Then moth using its legs and head, wriggles out of the cocoon. After emergence, moths stretch its wings for about 5 min. After passing urine especially male moths are seen moving actively in the tray.

5.5 Coupling and Decoupling

After emergence of moths, the males and females are picked and allowed to mate as per the desired combinations. This is known as Pairing (Fig 5.2). The female moths are collected in the tray into which the desired male moths are left over the female gently. The moths pair within 5-10 minutes. The left over male moths are collected into another tray. If the males available in excess, they should be preserved at 5° C for later use. Each paired moths are kept in cellules arranged in a tray. All the trays are kept in dark room for about 3-4 hrs with a temperature of 25°C and 75-80 % humidity.

De-coupling

De-coupling is the process of separating the moths after 3 - 4 hours of mating. The moths are separated by holding the female lightly and moving the male sideways using the fingers. This facilitates easy separation without injury to the female reproductive organs. The trays in which the female moths are kept gently tapped to induce the moths to urinate.

Fig 5.2 Pairing and depairing of moths

Second Pairing

Properly preserved male moths pair 8 times but with increase in frequency of mating fertilization rate decreases. Thus male moths can be used in pairing for 3 times. The male moths are preserved at 5°C temperature for about 4 – 5 days. Prior to second pairing the male moths preserved are released at room temperature for 5- 10 minutes.

5.6 Oviposition

After de-coupling the females are first placed on a paper and tapped to induce them to pass urine. Later female moths are placed on egg cards, covered individually with a cellule which helps to provide darkness avoid disturbance. The moths normally lay eggs from the afternoon onwards and reach peak stage by early night hours. This egg laying process is known as oviposition (Fig 5.3)

Fig 5.3 Copulation and Oviposition

The oviposition room is kept dark by closing the doors and windows. At the time of oviposition a temperature of 23 – 25°C and humidity 80 % should be maintained for egg laying. If the humidity is less than 80 % the gummy substance secreted by the female dries up on the ovipositor and obstructs egg laying. This results in less number of eggs inlaying, because most of the eggs remain in the body.

5.7 Summary

- Grainage operations are conducted under supervision of trained technical staff.
- Reproductive seeds are used for producing the seed cocoons which are required in large numbers for producing commercial seeds.
- Reproductive seeds are often multiplied in number in a series of breeding centers called Breeding-Station.
- Industrial seed are specific hybrids between 2 or more pure lines of races. These are produced in Grainages.
- There are three components in seed production. They are breeder's stock, basic seed multiplication, Industrial seed production.
- Seed organization is at 3 – tier or 4 – tier level.
- Selection of seed rearer is to be carried on according to the norms.
- Seed cocoons are procured on the basis of norms laid down.
- After confirming the commercial characters of cocoons the price is fixed as per the standards.
- Seed cocoons are transported safely from production centers to egg producing centers on the 5^{th} or 6^{th} day after spinning during early cool hours.
- The examination is of two types i.e., pupal gut examination and Forced eclosion. The identification of pebrine is crucial, thus cocoons are subjected to both type of tests.
- The cocoons are sorted to separate good and bad cocoons. Good cocoons are arranged ina single layer on bamboo tray, temperature range 23–26°C and 70–80 % humidity are required.
- Uniform eclosion of moths depends on the intensity and duration of light.
- Sex separation facilitates mating of desired variety. Sexing helps in true hybrid preparation.
- The best period of sex separation is when the pupae are 2 – 3 days old. Sex markings are clear in pupae/moths.
- The emergence can be adjusted by refrigerating the cocoons or pupae and are freezed for 7 days.
- It requires specific environmental conditions for cocoon or pupae before emergence of moths.
- On the day of emergence the room is illuminated at 4-6 a.m. Moths starts emerging from 6 - 8 a.m.
- Only healthy moths are used for pairing and kept for 3-4 hours.
- After mating time moths are de-paired.

- Male moths can be used for second pairing by preserving at 5°C temperature for about 4-5 days.
- 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.

Questions

I. Short Questions

1. What are reproductive seeds?
2. What are Industrial seeds/Commercial Seeds?
3. What are breeding Stations?
4. Define Grainage.
5. What is meant by foundation crosses?
6. What is meant by seed rearers?
7. What are the stages of price fixation?
8. Write the principle to calculate cost of 1 kg cocoons.
9. What is the safe period and time for transport of seed cocoons?
10. Why preliminary examination of seed cocoons is required?
11. Mention the methods of preliminary examination of seed cocoons.
12. What is forced eclosion test?
13. How is pupal examination conducted?
14. What is Cocoon sorting?
15. Mention temperature and humidity required for preservation of seed cocoons.
16. How sex separation is helpful in hybrid egg production?
17. Draw neat diagram of male and female pupae.
18. Define synchronization.
19. Define moth emergence and mention time of emergence.
20. What is sex-limited breed.
21. Define Pairing and depairing.
22. Define mating and mention duration of mating time.
23. Mention temperature and humidity required during pairing.
24. What is second pairing?
25. What are stages suitable for refrigeration of pupae?
26. Define Oviposition.
27. What happens if the humidity is less during oviposition?
28. What are the environmental conditions required for oviposition?
29. What are the uses of Grainage registers?
30. Mention some of the Grainage registers?

II. Essay Questions

1. Write about three tier P3 and four tier P4 system of egg production.
2. Mention the norms for procurement of seed cocoons.
3. Write short notes on

a. Industrial/Commercial seed b. Seed rearer

4. Calculate the cost of 75 kg bivoltine numbering 700 per kg and standard rate being RS. 125. Calculate the total amount.
5. Calculate the cost of 55 kg multivoltine numbering 800 per kg and Standard rate being RS. 110, Calculate the total amount.
6. How is preliminary examination conducted on seed cocoons?
7. Write short notes

   a. Reproductive Seed b. Transport of Seed Cocoon.
8. Write about the preservation of seed cocoons.
9. Write short notes on
   a. Sex separation b. Synchronization.
10. Describe moth emergence.
11. Detail about Pairing and Depairing.
12. Write about the Grainage registers and their uses.

Ψ

UNIT 6

SEED PRODUCTION

Structure

Learning Objectives

- Preparation of layings
- Sheet and loose eggs
- Mother moth examination
- Surface sterilization and assessment of layings
- Incubation of layings

6.1 Introduction

Seed Production is one of the critical important processes of Grainage. The production of good, disease-free layings improves economics of sericulture. But diseased egg production would be a great threat to sericulture. As it has evidence from the history. This activity is to be carried on with lot of care and technique. Pebrine is a dangerous disease, which transmits through eggs. Thus examination of pupae before moth emergence and moth examination after oviposition is compulsory so as to confirm disease-free eggs. All the Grainage operations are carried on after perfect sterilization of rooms, equipment and even hands and foot of technical persons who are involved to carry on the operations. This kind of check at every stage is to reduce the incidence of the disease and also to improve the quality of silkworm eggs. Thus, it is necessary to know about the various stages in egg production.

6.2 Preparation of Layings

There are two types in preparation of layings.

a. Flat card or sheet egg method
b. Loose Egg method

6.3 Sheet Eggs (Flat card method)

It is used for industrial egg production on a very large scale. Egg sheets contain 20-42 squares, arranged in 60 x 90 cm tray. Each female moth is kept in a square and covered with cellule. Such trays are arranged in one tier in a wooden rack kept in oviposition room. The room should be maintained dark and optimum temperature of 23 – 25°C and humidity 80 % for better egg laying. The egg sheets along with the moths are taken for moth examination hall after 24 hours of egg laying. The moth samples are taken for crushing and examined for pebrine disease. If a certain percentage of the sample is found to have pebrine, the entire lot is discarded and burned.

Fig 6.1 Sheet egg preparation

Advantages

1. Pebrine inspection is perfect.
2. Egg laid by pebrine infected moths are eliminated.
3. Surface sterilization of eggs and distribution of eggs to farmers is easy.
4. Incubation of eggs is also easy.

6.4 Loose Egg Preparation

It is similar to the flat card method except that the eggs are laid on smooth side of a starched paper. Preparation of loose eggs has specific advantage. A large number of moths are allowed to lay eggs and only sample of moths are drawn for examination. As the commercial seeds are required in large quantity and the preparation of eggs in loose form is similar. Thus, loose egg method is adopted for preparation of commercial seed (Fig 6.2 to 6.5).

Fig.6.2 Smearing starch paste

Fig.6.3 Moths laying eggs on starch sheet

Fig 6.4 Soaking of sheets

Fig. 6.5 Loose egg collection

About 100 – 120 grams of arrow root or starch is added to one liter of water and boiled to prepare a paste. After cooling, smear paste uniformly on craft sheet (90 x 60 cm) or cloth in thin layer and dried. These dry sheets are spread in a wooden tray. Female moths (30–200) after urination are transferred in the ovi-position room and moths are allowed to lay eggs for 1-2days on the sheets. On the next day moths are removed for examination. After examination the egg sheets/cloth are soaked in water for 15 minutes. It is gently brushed to remove the eggs from the cards. Then eggs are collected by removing the sheet and filtering through a muslin cloth. These eggs are soaked in 0.5 % bleaching powder solution for 5-10 minutes to remove the gum and avoid formation of clumps of eggs. Eggs are washed in water and transferred to salt solution with a specific gravity of 1.06 – 1.09 at room temperature. The fertilized eggs having higher specific gravity sink in the solution. The floating dead eggs with low specific gravity are separated and rejected. The good eggs are washed again in water then surface sterilized with 2 % formalin solution for 20 minutes. Again wash the eggs in water and dried in shade. These eggs are packed in loose egg boxes; each box consists of 30,000 eggs, which is equivalent to 50 Dfls. If one gram of eggs approximately weighs 1600 eggs, then one box will have

$$= \frac{30{,}000}{1{,}600} = 18.75 \text{ grams.}$$

The boxes are sealed and labeled. The label has the details of race, date of egg laying, quantity of eggs, name of the grainage, technician signature. In multivoltine, a gram of eggs has about 2000 eggs while 1800 in bivoltine.

Fig 6.6 Degumming of loose eggs

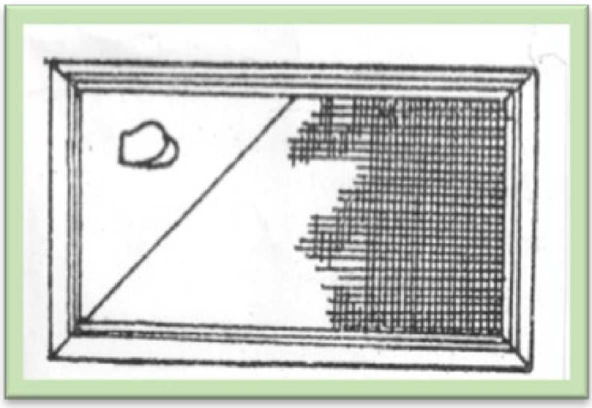


Fig 6.7 Loose egg box

Advantage of Loose Eggs

1. Egg Processing and handling is easy.
2. Dead and unfertilized eggs are removed.
3. A unit number of viable (possible) eggs can be supplied.
4. It saves space in storage.
5. Transportation is easy.
6. Best method for commercial egg production.

6.5 Mother moth examination

Pebrine is a transovarially transmitted disease. The infected mother moth transmits this disease through the eggs to next generation. The elimination of eggs laid by a diseased moth is important. Hence it is necessary to examine the mother moth. The moths after egg laying are examined for pebrine disease. If there is lack of time, moths are dried, preserved and examined later.

6.5.1 Methods of Moth Examination: There are two methods.

1. **Fresh moth or green moth examination:** In this the moths are examined soon after egg laying when the seeds are required for immediate use.

2. **Dry Moth Examination:** When the eggs are to be hibernated, the moths can be dried and tested in leisure time. The samples of 30 moths are oven dried at 65°C to 75°C for 6 hrs. There should not be any fluctuation in temperature, leading to un identification of pebrine spores. The spores are seen very clearly.

6.5.2 Kinds of examination

There are two kinds of moth examination depending upon the purpose for which the seed is used *viz*., reproduction purposes or commercial purposes.

6.5.2.1 Individual moth examination

It is conducted for producing reproductive seeds. Thus each and every moth is examined individually to make sure that they are completely free from pebrine disease. After oviposition the moths are transferred to the mortar and crushed with the help of pestle by adding 2-3 drops of 2 % KOH solution. A smear is taken on to a glass slide and fine smears are arranged on each slide. The smear are covered with cover slip and observed under the microscope with 600 magnifications. If at all any incidence of pebrine, entire lot of moths and eggs are rejected and burned.

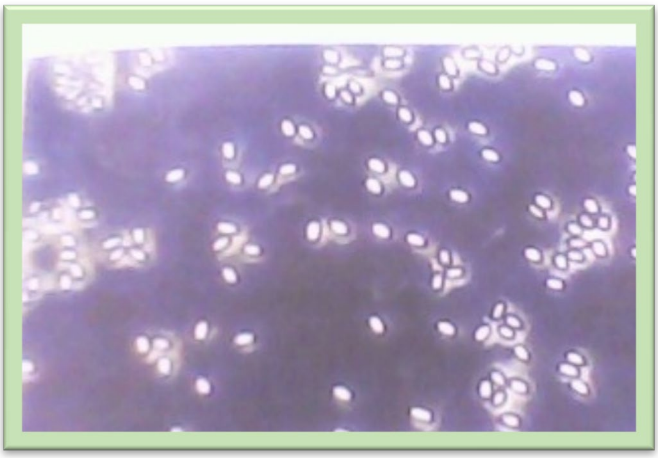


Fig.6.8 Microscopic view of pebrine spores.

Advantage

1. Perfect method
2. Easy identification of pebrine spores.
3. This method is must for reproductive seed or egg production.

Disadvantage

1. This method is laborious.
2. Time Consuming.

6.5.2.2 Mass Moth Examination

It is followed in commercial/industrial seed production where only few samples of moths are examined in groups of 10 – 30.After oviposition, moths are taken in groups and grinded by adding 90 – 100 ml of 0.5 % potassium carbonate solution. Moths are grinded at 10,000 rpm by adding Potassium bicarbonate solution to separate pebrine spores from the tissues. After that, crushed material is filtered through a coarse filter paper. And filtrate is centrifuged at 2000 rpm for 3 minutes and to dissolve the sediment in 2-3 drops of 2% KOH. The smears are taken from the solution on to glass slides and observed under the microscope for pebrine spores.

6.5.2.3 Identification of Pebrine Spores

Pebrine spores are identified at 600 magnifications. These spores appear as shinning oval bodies under the microscope. Though the spores are colourless with a lustre, decreased intensity of light gives a satisfactory contrast and shade, making the observation clear (Fig 6.4).

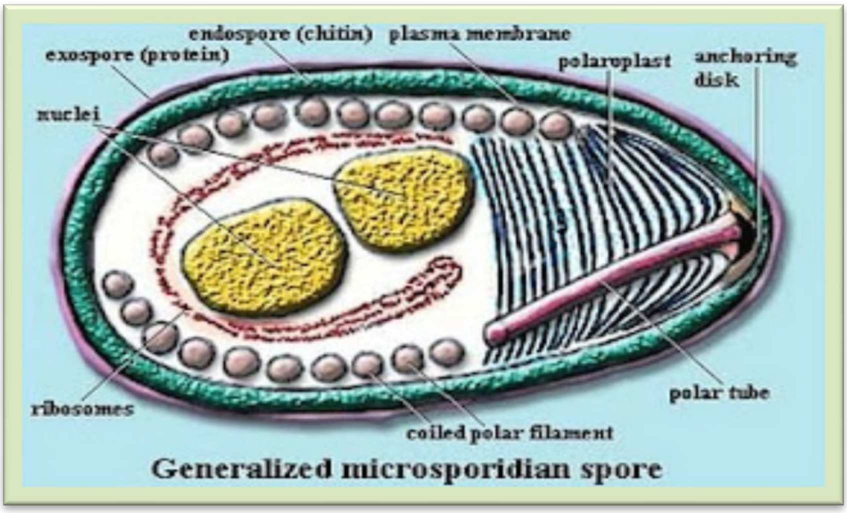


Fig 6.9 Structure of single Pebrine spore

6.6 Surface Sterilization

The eggs are processed after moth examination. While egg laying, the surface of egg may be stained with moth urine and scales and disease causing germs. Thus the egg surface has to be washed and surface is disinfected to remove the stains and surface contaminations. It is called egg processing or surface sterilization. Only sheets with standard layings after removing the poor layings and dead layings soaked in 2 % formalin for 5 – 10 minutes. Then eggs are washed in water and allowed to dry.

6.7 Assessment of layings and incubation

The egg sheets sometimes contain deformed eggs, poor eggs, unfertilized eggs, diseased eggs which are identified and marked during moth examination. These eggs are removed from the egg card. The egg processing refers to sorting of good eggs, rejection of defective eggs and removal of surface stains and infections by following suitable procedures. Unfertilized and dead eggs in loose egg s are separated by dipping them in salt solution. All dead eggs float are easily separated.

6.7.1 Characters of good laying

The total number of eggs laid by a single female moth is called laying. Only good layings are to be supplied to the farmers.

a) Each laying should have minimum 300 eggs.
b) Layings with less fertilized eggs are not considered.
c) There should not be any piling of eggs.
d) The eggs are laid in a single layer, side by side.
e) Good laying has maximum number of eggs.
f) The disease free laying is called good laying.

6.7.2 Incubation

Incubation of silkworm eggs aims at uniform development of the embryo thereby securing uniform hatching through proper maintenance of environmental conditions. Incubation greatly influences the voltinism character of the egg in the succeeding generation and also the larval growth and the success of the cocoon crop and cocoon quality. Incubation is done by using incubator, in which temperature and humidity is maintained automatically. Eggs are incubated at 24-25°C and 75-80 % RH till its distribution to farmers or reaches to head pigmentation stage.

If eggs are not distributed before 48 hours of hatching a black spot appears on the egg. This condition is referred as 'Head Pigmentation' stage. One day before hatching, the eggs turn black or blue in colour. This is referred as body pigmentation stage or "blue eggs". These eggs are placed in black boxes and covered with black cloth or paper and kept in dark place. So the hatching can be made more uniform on the next day morning.

If hatching has to be delayed after incubation has started this can be done by storing the eggs in cold storage room at 5°C on the 2^{nd} and 3^{rd} day of incubation for a week. If hatching has to be delayed at the blue egg stage this can be done by storing the eggs at 5°C for a week. If brushing has to be delayed after hatching, the newly hatched larvae can be stored for 3 days at7.5 – 10°C.

Fig 6.10 Incubator

6.11 Incubator Tray

Fig 6.12 Blue egg stage

Fig 6.13 Black boxing of eggs

6.7.3 Methods of Incubation

There are two methods *i.e.*, constant temperature incubation and raised temperature incubation.

Constant Temperature Incubation

In the incubation room optimum humidity should be 80 – 85 %. Optimum temperature for the incubation of non-hibernating eggs and eggs after acid treatment for immediate hatching should be 24 – 25°C right from the beginning.

Raised Temperature Incubation

It is used mostly for incubating hibernating eggs. The eggs after release from cold storage, are preserved at 10-15°C for three days, at 18-20°C for two days, at 23-24°C for four days and then at 25-26°C till hatching.

Summary

- Seed production is one of the critical and important processes of Grainage.
- After decoupling, female moths are placed on a paper (egg card), covered with a cellule and kept in darkness for 24 hrs.
- In case of loose egg preparation, moths (50-100) are released in a tray and kept in darkness for 24 hrs.
- Multivoltines lay 300 – 400 eggs, Uni and Bivoltines lays 400 – 500 eggs in 24 hrs.
- The temperature of 24°C and 80 % humidity are maintained for good egg laying.
- Mixed egg laying has two methods i.e., Flat card and Loose egg method.
- In flat card method eggs are prepared on egg sheets by individual moths and moth examination is conducted individually for pebrine spore.
- Moth examination is aimed to assess the pebrine free egg preparation.
- Pebrinized eggs are completely rejected.
- Method of moth examination are of two types i.e., fresh moth or green moth examination and dry moth examination. Kinds of examinations are of two types *i.e.*, Individual moth examination, Mass moth examination.
- Moths are crushed to paste by adding 2-3 drops of 2 % KOH and smears are observed under microscope at 600 magnifications.
- Pebrine spores appear as shining oval body, colourless with a luster, decreased intensity of light gives a contrast.
- Sterilization is to eliminate harmful microorganisms, gum, and scales on the egg surface and also to disinfect the egg surface is carried with 2 % formalin for 5- 10 minutes.
- The sorting of eggs into good and bad is called assessment of eggs. It is aimed to identify all bad eggs and elimination.

- Incubation aims at uniform development ensuring uniform hatching through proper maintenance of environmental conditions.
- In Constant temperature incubation the temperature is constant till hatching. It is used for acid treated eggs, non- hibernating eggs.
- Raised temperature incubation is for hibernating eggs, the temperature is raised from 10-15°C to 25- 26°C till hatching.
- Before 48 hours of hatching a black spot appears on the egg. This condition is referred as 'Head Pigmentation' stage. One day before hatching, the eggs turn black or blue in colour. This is referred as body pigmentation stage or "blue egg".

Questions

I. Short Questions

1. Define oviposition.
2. How much time is required for pairing and egg laying?
3. What is the difference between flat egg card and loose egg preparation?
4. What are the types in preparation of egg?
5. What are the best methods of commercial and reproductive egg preparation?
6. Why starch is applied to craft paper in loose egg preparation?
7. What are the chemicals used in egg preparation?
8. What are the advantages of loose eggs?
9. What are the contents of egg label?
10. Define moth examination.
11. Mention methods of moth examination.
12. When is fresh moth examination conducted?
13. What are the kinds of examination?
14. Define Mass moth examination.
15. How is pebrine spore identified?
16. Define surface Sterilization.
17. What is the need for surface sterilization?
18. What is the assessment of layings?
19. Write the characters of good laying.
20. What is the best time for disposal of eggs?
21. How much time is required for egg laying?
22. Define Incubation of eggs.
23. Mention methods of Incubation.
24. What is the optimum temperature, humidity to be maintained for incubation?
25. Define Blue Eggs.

II. Essay Questions

1. Write the preparation of flat card egg method.
2. Describe loose egg preparation.
3. How does moth examination is helpful for quality Dfls production?
4. Define the process of mother moth examination.
5. Write short notes on
   a. Individual moth examination b. Ovi-position.
6. Write short notes on
   a. Mass moth examination. b. Flat card method.
7. Write short notes on
   a. Methods of moth examination. b. Disposal of dfls
8. Write short notes on
   a. Surface sterilization. b. Good Layings.
9. Detail about incubation of silkworm eggs.

Ψ

UNIT 7

ACID TREATMENT AND HIBERNATION SCHEDULES

Structure

Learning Objectives

- Different types of eggs
- Physical and chemical stimulants
- Types of acid treatment
- Hibernation schedules of eggs

7.1Introduction

In silkworm rearing it is important not only to produce silkworm eggs of high quality but also to carefully protect and preserve them to ensure good and uniform hatching. If univoltine eggs are left after ovi-position without any treatment will undergo diapause, hence no hatching occurs. But the bivoltine eggs if incubated at high temperature become hibernating or black eggs and do not hatch for the second time during the year. However in order to meet the need for multiple rearings in a year it is necessary to hatch the eggs collected in spring. When the eggs of bivoltine are incubated in the dark at low temperature, they become non-hibernating eggs which have several drawbacks. The most important point to be considered in the prolongation of the storage period is by utilizing the diapause. During diapause stage of eggs, for an adequate length of time certain temperature needs to be maintained to ensure uniform hatching of eggs.

7.2 Types of Eggs

The silkworm eggs are of two types *i.e.*, diapausing and non- diapausing eggs. After ovi-position further processing of the eggs depend upon their diapausing or non-diapausing nature. Generally univoltines lay diapausing eggs where as multivoltine lays non-diapausing type of eggs.

7.2.1Handling of eggs: The important factors in egg handling are as follows.

1. The eggs are handled depending on the nature of the eggs.
2. Hatching of eggs has to be obtained in desired time.
3. Conditions that are required should be maintained for various purposes.
4. Disinfection of eggs

Eggs are processed according to the type of breeds *i.e.* whether they are produced by multivoltine or bivoltine or univoltine breeds.

7.2.1.1 Methods of Handling Eggs

A. Handling of Multivoltine Eggs.

These breeds produce non-hibernating eggs and as such they hatch in 10 – 11 days after egg laying. If hatching has to be delayed, the eggs on the second day of laying should be placed for preservation at 5°C with 75- 80 % humidity for 20 days. During this period eggs can be released for incubation on any day.

B. Handling of Bivoltine Eggs

These breeds lay hibernating eggs, which do not hatch in 10 – 11 days after egg laying as these types of eggs undergo diapause. However they can be made to hatch by following artificial treatment. Depending on the requirement of their hatching, they are processed by different methods.

7.3 Physical and Chemical Stimulants

These are stimulants which are very useful for artificial hatching of eggs. The acid treated hibernating eggs can be utilized after 10 days up to one year at any given time.

The following physical and chemical stimulants are used in artificial hatching process.

Physical Stimulants	Chemical Stimulants
1. Lowest Temperature.	1. Hydrochloric acid (HCL).
2. Dipping in hot water.	2. Nitric Acid (HNO_3).
3. High electric stimulation.	3. Sulphuric Acid (H_2SO_4).
4. Rubbing with brush or feather.	4. Aqua regia.
5. High atmospheric pressure.	5. Acetic Acid.
6. Ultra hi- frequency vibration.	6. Sodium chloride.
7. Exposing to sunlight.	7. Hydrogen Peroxide.
8. Univoltine race/Ultra short waves	8. Enzyme treatment.
9. Exposing to Oxygen	9. Ozone Treatment.

7.4 Types of Acid Treatment

The hibernating eggs or diapause eggs do not hatch in 10 – 12 days. These eggs are treated with Hydrochloric acid (HCL) to break the diapause. This Process is known as acid treatment. Acid Treatment is to be conducted before first stage of embryo development. It is not advisable to carry on acid treatment before 1- 10 hrs of egg laying which leads to death, irregular hatching. Treatment can be done after 15 hours. However, treatment between 20 -24 hours is better for good results. Acid treatment after 48 hours leads to irregular hatching.

There are two methods. They are

1. Hot Acid Treatment.   2. Cold Acid Treatment

1.Hot Acid Treatment

In hot acid treatment eggs are dipped in HCL having specific gravity of 1.075 at 46°C for 5-6 minutes. It is always necessary to maintain proper specific gravity of HCL. Before heating, the specific gravity of the acid is first adjusted to room temperature. HCL should not be heated directly. Hot acid treatment bath is used for treatment, which favors to heat HCL indirectly. Acid is taken into a glass jar and placed in treatment bath. When the temperature reaches to 46°C the eggs are dipped. The dipping time is different for different types of eggs. After treatment eggs are washed in water. Hot acid is treated eggs after 24 hours, otherwise eggs cannot withstand (Fig 7.1).

Fig 7.1 Hot Acid Treatment Bath

Cold Acid Treatment

It is also called as room temperature acid treatment. There is no heating of acid; treatment is carried at 23 – 30°C temperature to eggs after 24 hours of ovi-position. The treatment is conducted on first embryo stage. Further the eggs are likely to get separated from the egg card and the unfertilized eggs crumble, which help in their removal. In this method HCL 1.110 specific gravity at 15°C room temperature is used to treat the eggs. Eggs are treated with 2 % formalin before acid treatment for egg aglutinization. After completion of acid treatment, the eggs are to be washed in running water for 30 minutes to remove acid traces.

7.4.1 Acid Treatment of Loose Eggs

The loose eggs after sterilization are kept in porous plastic container for acid treatment. The process of treatment is similar as explained earlier. After washing in water eggs are dried on a smooth cloth.

7.4.2 Stopping of Acid Treatment:

Generally it is not advisable, if inevitable eggs are kept at 5°C for 5 days, up to 7 days at 2.5°C. This process is to be carried out later they are processed as detailed earlier. The eggs are kept at 15 - 25°C for 2 hrs and slowly brought to 2.5°C, such procedure ensures the safety of the embryo. During egg preservation 70 - 80% humidity is to be maintained.

The hibernated eggs are acid treated to prevent diapause and stored at 5°C in cold storage for three days before releasing.

7.5 Hibernation schedules

There are two types i.e., Short term and Long term chilling.

7.5.1Short Term Chilling

Temperature of 25°C and 70 – 80 % humidity is maintained during oviposition. These eggs are left for 30 – 35 hours, at 25°C to reach spoon head stage and then preserved at 5°C with 75 – 80 % humidity for 45 – 50 days. If chilling has to be prolonged beyond 60 days, it is first carried out at 5°C for about 40 days and then at the lower temperature of 2.5°C. The eggs can be released after 35 days and up to 50 days. While releasing, the eggs are kept at 15°C for 6 - 12 hours and then at 25°C for 3 – 4 hrs. The eggs are treated with HCL of 1.100 Specific gravity at 47.8° C for 5- 6 minutes. Then eggs are washed in running water to remove all the traces of acid. Thus the eggs could be made to hatch in 45 – 60 days after egg laying.

7.5.2 Long Term Chilling

The eggs are kept at 25°C for 40 – 50 Hrs. and then preserved at 5°C with 75 – 80 % humidity for 50 – 70 days. Eggs turn to brown colour and reach to spoon head stage. The eggs can be released on any day during this period. While releasing they are preserved at 15°C for 6- 12 Hrs. and then at 25°C for 3- 4 hrs. Later eggs are treated with HCL having a specific gravity of 1.100 at 47.8°C for 5 min. After treatment eggs are washed in water to remove all traces of acid. Thus eggs treated can be made to hatch in 60 – 80 days after they are laid.

7.5.3 Transportation of Eggs

It means carrying the silkworm eggs from the Grainage to the rearing centers. During the period of transportation, friction, air, light conditions, saltiness and high temperature should be avoided. The safe transportation of eggs is highly essential in order to protect the embryo and to ensure good hatching results, which affect the yields and quality of cocoon crop. The silkworm eggs should be transported during the cooler hours (morning/evening).Eggs should not be transported during the hot hours or in rainy weather. The egg cards are loosely placed in a wooden egg carrier/perforated paper cover. For loose eggs also same method is adopted. It is preferable to carry the eggs in specially made egg boxes, with perforations for aeration and provision for maintaining humidity.

Fig 7.2 Egg transportation devise

7.7 Summary

- There are two types of eggs *i.e.,* Diapausing and non-diapausing eggs.
- A hormone in diapausing eggs is responsible for inhibition of embryo development whose activity is neutralized by cold temperature.
- Handling of eggs refers to processing of eggs under optimum conditions to obtain hatching whenever desired.
- Storage of spring eggs, autumn eggs are different.
- Physical and chemical stimulants are useful for artificial hatching of eggs.
- The acid treated hibernating eggs can be utilized after 10 days up to one year at any given time.
- Acid Treatment is for breaking the diapause eggs. Inorganic acids are better for treatment especially HCL is commonly used.
- Prior to acid treatment formalin treatment is necessary to sterilize the eggs and to fix the eggs to egg card.
- Acid treatment is conducted before first stage (between 20- 24 Hrs. after oviposition) .
- Acid treatment is of two types i.e., hot acid and cold Acid treatments.
- In hot acid treatment, eggs are dipped in HCL of 1.075 Specific gravity at 46°C for 5-6 minutes.
- Cold acid treatment is conducted at room temperature. Eggs are treated with HCL of 1.110 Specific gravity at 15°C at room temperature.
- Acid treatment can also be done after chilling. It is of two types *i.e.*, Short term and Long term chilling.
- Eggs are transported during cooler hours of the day. Eggs are loosely placed in a wooden carrier/perforated paper cover.

Questions

I Short Questions

1. Mention the different types of eggs.
2. What are the factors in handling eggs?
3. Define handling of the eggs.
4. What are the methods of handling the eggs?
5. Why storage of eggs is necessary?
6. What is the use of stimulants?
7. Mention some physical and chemical stimulants.
8. Define Acid treatment.
9. What is the best acid for treatment of eggs?
10. What is the best age for acid treatment?
11. What is the specific gravity in hot and cold acid treatment?
12. Mention methods of acid treatment after chilling.
13. What is transportation of eggs and mention best time for transportation?

II Essay Questions

1. Write the types of acid treatment?
2. Write about acid treatment after chilling.
3. Write short notes on
   a. methods of handling eggs b. Stimulants.
4. Write about hibernation schedules of eggs?
5. Write short notes on
   a. age of eggs in acid treatment b . Short term chilling.
6. Write short notes on
   a. Transportation of eggs b. stopping of acid treatment.
7. Write short notes on
   a. Long term Chilling b. Acid treatment of loose eggs.

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UNIT 8

SEED ECONOMICS

Structure

8.1 Introduction
8.2 Economics for 10 lakhs Cross breed layings production
8.3 Summary

Learning Objectives

After studying this chapter, the students will be able to

- Understand the various factors that are involved in egg production
- Amount of raw material to be purchased and how the economics are calculation to know the production cost.

8.1 Introduction

Grainages are aimed to produce silkworm eggs commercially and are sold to the farmers for commercial cocoon production. The production of egg is influenced by various factors. The seed cocoons are produced in seed areas under scientific guidance and supervision, cost of seed cocoons is generally fixed by the state government from time to time and seed cocoons are offered about 20-25 % higher rates than hybrid cocoons. The quality of seed cocoons has direct relation in producing more number of disease free layings. Since nearly 60 percent of the cost of production of seed goes to the cost of the cocoons, the egg producer must concentrate on procuring good quality seed cocoons.

Generally the following are considered for working out the economics of grainages.

1. Cost of seed cocoons.
2. Establishment charges.
3. Wages
4. Depreciation cost on equipment.
5. Interest on revolving capital.
6. Cost of chemicals, rent, electricity and water charges.
7. Total Dfls produced. In any case one must be sure of producing disease-free layings at a lower cost utilizing all the latest easy techniques.

   Utilization of seed cocoons has direct relation to the cost of seed production. If the quality of seed cocoons is good, then recovery of Dfls is high.

Table 8.1. Economics for 10 lakhs Cross breed (PM x CSR2) layings production

Particulars	Details (Figures in lakhs)
I. Seed Cocoon cost	
1.Seed cocoons purchased	**33.20 (Mv)** **16.60 (Bv)**
2. Defective cocoons / Grainage mortality (20 %)	**6.64 (Mv)** **3.32 (Bv)**
3.Good cocoons to be used for Dfls preparation	**26.56 (Mv)** **13.28 (Bv)**
4.Percentage of Dfls from total seed cocoons (item 3)	**30%**
5.Total Dfls produced	**10 lakhs**
6.Cost of multivoltine seed cocoons @ Rs.500 per 900 cocoons (approx. 3689 kgs)	**Rs. 18.26**
7.Cost of bivoltine seed cocoons @ Rs.700 per 650 cocoons (approx. 2554 kgs)	**Rs. 17.88**
8. Total cost of seed cocoons (6 + 7)	**Rs. 36.14**
9. Recovery from pierced cocoons	**Rs. 7.05**
a. Bivoltine cocoons (approx. 425kgs @ Rs. 900)	**Rs. 3.82**
b. Multivoltine cocoons (approx.) 461 kgs @ Rs. 700	**Rs. 3.23**
10. Total cost of seed cocoons (8-9)	**Rs. 29.09**
II. Expenditure (Recurring)	
a. Labour charges	**Rs. 4.00**
b. Cost of egg sheets	**Rs. 2.00**
c. Cost of chemicals	**Rs. 0.50**
d. Rent etc	**Rs. 3.00**
f. Miscellaneous	**Rs. 1.00**
Total	**Rs. 10.50**
B. Non-Recurring	
a. Depreciation on cost of equipment	**Rs. 1.00**
b. Interest on revolving capital	**Rs. 2.00**
Total	**Rs. 3.00**
Total cost of layings	**Rs. 42.59**
Cost of 100 CB layings	**Rs. 426.00**

Note: This is calculated based on the present standards; however it may vary according to demand, season and place.

Table 8.2. Economics for 10 lakh bivoltine (Double hybrid – FC 1 x FC2) layings production

Particulars	Details (Figures in lakhs)
I. Seed Cocoon cost	
1.Bivoltine Seed cocoons purchased	40.00
2. Defective / Grainage mortality (20 %)	8.00
3.Good cocoons to be used for Dfls preparation	32.00
4.Percentage of Dfls - total seed cocoons (approx. on item 3)	32%
5.Total Dfls produced	10 lakhs
6. Cost of FC 1 bivoltine seed cocoons @ Rs.700 per 650 cocoons (3077 kgs)	Rs. 21.53
7. Cost of FC 2 bivoltine seed cocoons @ Rs.700 per 650 cocoons (3077 kgs)	Rs. 21.53
8. Total cost of seed cocoons (6 + 7)	Rs. **43.06**
9.Recovery from pierced cocoons	**Rs. 6.92**
a. FC1 - Bivoltine cocoons (approx. 385 kgs @ Rs. 900)	Rs. 3.46
b.FC2 - Bivoltine cocoons (approx. 385 kgs @ Rs. 900)	Rs. 3.46
10. Total net cost of seed cocoons (8-9)	**Rs. 36.14**
II. Expenditure (Recurring)	
a. Labour charges including sex separation	Rs. 5.00
b. Cost of egg sheets	Rs. 2.00
c. Cost of chemicals	Rs. 1.00
d. Rent etc	Rs. 3.00
e. Miscellaneous	Rs. 1.00
Total	**Rs. 12.00**
B. Non-Recurring	
a. Depreciation on cost of equipment	Rs. 1.00
b. Interest on revolving capital	Rs. 2.00
Total	Rs. **3.00**
Total cost of layings	**Rs. 51.14**
Cost of 100 Double hybrid (FC 1 x FC2) layings	**Rs. 511.40**

Note: This is calculated based on the present standards; however it may vary according to demand, season and place.

8.3 SUMMARY

- Main aim of Grainage is to produce Dfls at an affordable cost.
- Approximately, 60 % of the Dfls production cost is being incurred towards the seed cocoons.
- Items like investment, recurring, non-recurring are to be considered for calculation of cost of production of silkworm eggs.

QUESTIONS

Short Questions

1. What is the aim of a Grainage?

2. What are the items to be considered for calculating the cost of production of eggs?

Essay Questions

1. Estimate the cost of production of 10 lakh CB Dfls production.

GLOSSARY

Anaphae Silk	A univoltine green silkworm (20 - 100) collectively producing silk cocoons
Ant	A common name to freshly hatched silkworm larvae.
Antennae	A pair of sensory receptive organs present on the dorsal side of the head
Ant Well	Equipment used to prevent crawling of ants onto rearing trays
Acid Treatment	A process to make the eggs to hatch especially bivoltine eggs
Breeding Stations	Place to multiply reproductive seeds.
Bivoltine	The silkworms have two generations in a year.
Cellule	A plastic black conical cup used to cover paired moths and female moth during ovi position.
Chawki worms	Worms of I to III instar age.
Cocoon	A compact structure spun by silkworm larvae as a protective covering for undergoing population.
Seed Crop	Seed used for the continuation of silkworm life Cycle.
Crumpled Wings	Wings which are having numerous folds but not uniform.
De-floss	Removing of floss before moth emergence
DFL	Disease Free Laying
Disease	Any deviation from the regular physiological activities in an organism
Disinfection	This is the process of making the room and application clean and hygienic
Domestication	Rearing any animal under domestic conditions.
Eri silk	A domesticated silkworm *Philosamia ricini* feed castor leaves to produce white or brick-red silk.
Floss	An outermost loose, fragmented layer of cocoon.
Grain	The term given to the eggs of silk moth.

Grainage	A center aimed to produce disease free silkworm eggs.
Hygrometer	It is a device to measure humidity.
Instar	The stage between two moults in larval development of an insect
Incubation	A process aimed for uniform development of egg which ensures uniform hatching
Insect	An animal having 3 pairs of legs present on the ventral side of the thorax
Kego	A common name of freshly hatched larvae
Labium	It is a part of mouth parts present on the ventral side of the head (lower lip).
Larva	A stage in which animals of class Insecta hatch from the egg. It is capable of feeding for itself and for the future stages of life cycle.
Laying	A number of eggs laid by a single silkworm.
Lustrous	Glittering or shinning
Mandible	Teeth like structure with cutting edge present as a Part of mouth parts of larva.
Micropyle	A small microscopic opening present on anterior part of egg.
Morphology	Study of external structure of an organism
Moultinism	It is racial character which indicates the number of moults during larval stage of an insect.
Muga Silk	A silkworm, *Antheraea assamensis* feeds on Som and Soalu to produce golden yellow silk.
Multivoltine	The silkworms have many generations in a year.
Moulting	Shedding of old skin and forming new skin.
Metamorphosis	Change of forms or character by natural growth or development in the life of an insect starting from egg and evolving with adult.
Moth examination	It is examine moths after oviposition to know pebrine infection
Moth emergence	The process of moth coming out of cocoon
Mortality	It denotes the death rate of an organism.
Non- hibernating eggs	These breeds hatch in 10-11 days after laying.
Oviposition	Process of laying of eggs.
Pupa	Stage between larva and adult of endoptery got a insect, in which commotion and feeling cease but great development changes occur
Pebrine	A transovarially transmitted disease.
Pectinate	Antenna possessing numerous hairs which look like a comb.
Prolegs	3 pairs of thoracic legs of larva which are single clawed.

Pro thetel	An intermediate form between larva and pupa of an Insect.
Reproductive seed	Seed cocoons which are required in producing commercial seeds.
Silk	A fibrous proteinous secretion secreted by certain Insects.
Spinneret	It is a mouth part meant for secretion of silk
Sexual Dimorphism	It is a phenomenon where male and female are identified by their external morphological features.
Spiracle	An opening meant for respiration in insects
Synchronization	The moths of different races are made to hatch simultaneously on the same day, so are available for hybridization.
Sterilization	A process to eliminate harmful micro-organisms, and to make the room clean and hygienic.
Tasar Silk	A wild silk produced by *Antheraea mylitta* which feed on *Terminalia tomentosa*.
Univoltine	The silkworms have only one generation in a year.
Voltinism	It is a character which indicates the number of generations per year

REFERENCES

1. Text book on Tropical Sericulture Japan Overseas Cooperation Volunteers, Japan, 1975.
2. Hand Book on silk worm Breeding, ESCAP, United Nations, Thailand, 1990.
3. Manuals on Silkworm Seed Production, NCERT, New Delhi, 1999.
4. Principles of Sericulture, by Hisao Aruga, Oxford and IBH Publishing Co. Ltd., New Delhi, 1994.
5. Techniques of Silkworm Rearing in the Tropics, ESCAP, United Nations, New York,1993.
6. Appropriate Sericulture Techniques by Manjeet S. Jolly, ICTRTS, Mysore, 1987.
7. Manual on Silkworm Egg Production, by Narsimhanna, CSB, Bangalore, 1998.
8. Hand Book of Practical Sericulture by Ullal and Narsimhanna, CSB, Bombay, 1981.
9. Pattu Parishrama by Dr.P.Srinivas (ed.) A. Purushotham Rao, Telugu Academy, Govt. of Andhra Pradesh, 1996.
10. Pattu Parishrama by Dr. P. Srinivas (ed) A. Purushotham Rao, Telugu Academy, Govt. of Andhra Pradesh, 2000.
11. An Introduction to Sericulture by Ganga and Chetty, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, 1998.

12. Bulletins on Sericulture, CSB, Bangalore.
13. The Silkworm An Important Laboratory Tool, by Tazima, Kodansha Ltd., Japan,1978
14. New Illustrated Sericulture Reader, Central Silk Board, Bangalore, 1997.
15. Hand Book of Silkworm Rearing, by Tazima, Fuji Publishing Co. Ltd., Japan.
16. Text Book on Farm Maintenance and Seed Technology, by Adithya Kumar and Somi Reddy, BIE, Hyderabad, 1993.
17. Pattu Parishrama Practical Manual (Telugu) by Maruthi Ram and P. Srinivas, Telugu Academy, Hyderabad.
18. Comprehensive Sericulture Manual, Ebid, 1999.
19. Industrial Bivoltine Grainage – CSR & TI Project – 3 by Dr. Manjeet S.Jolly.
20. FAO Manuals on Sericulture – FAO of United Nation – Rome.

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SERICULTURE

Paper – III

Post Cocoon Technology

INDEX

UNIT 1

Silk Reeling Industry

Structure

Learning Objectives

After studying this unit, the student will be able to

- Know the importance of silk reeling industry
- Know how much scope is there for Industry

1.1 Introduction

The term '**Sericulture**' has originated from two French words, "**Seris**" meaning '**silk'** and '**Culture**' which means rearing. Sericulture is a science which deals with various aspects of silkworms. It's an Agro-based cottage industry, the end product of which is silk. Mulberry silk is also called **'Mori silk'** where as Non-mulberry silk is called '**Vanya silk**'.

What is silk?

It is a natural protein fiber secreted by silkworms in forming a filament about 400-1500m long, spun into a cocoon "shell" (protection to pupa inside)

Silk is combination of two proteins

Fibroin – inner core comprising 75% of silk

Sericin - outer gum comprising 25% of silk

These silk proteins are synthesized by silk glands present in silkworms.

Besides proteins, silk has small residues of fat, resin, minerals and waxy materials. Silk is "Queen of Textiles" and the only continuous filament among naturally occurring fibers.

1.2 Importance of Sericulture:

1. It's an agro-based cottage industry with very high employment potential, more than 60 lakh persons engaged in sericultural activities.

2. Provides vibrancy to village economics. Share of income to various groups are as follows:
    a. 56.8 % to cocoon growers (Silkworm rearers)
    b. 6.8% to reelers
    c. c) 9.1% to twisters
    d. 10.7% to weavers
    e. 16.6% to traders
3. Large part of income goes back to villages from cities.
4. Low gestation and high returns. It's a low volume and high value crop.
5. Highly women friendly occupation as 60 % of women are engaged in sericulture.
6. It's an ideal programme for weaker sections of the society.
7. It's a very eco-friendly activity.
8. Sericulture earns foreign exchange (>2000 crores) and silk items are exported to over 50 countries.
9. It satisfies equity concerns as money flows from high end groups to low end groups. Users belong to higher economic groups

Table: 1 WORLD RAW SILK PRODUCTION 2007- 09

Unit: Raw Silk,MetricTonnes

Country	Mulberry Raw Silk			Total Raw Silk		
	2007	2008	2009	2007	2008	2009
China	78000	70980	84000	108420	98620	104000
India	16245	15610	146322	18320	18370	19690
Japan	150	95	90	105	95	90
Brazil	1220	1177	811	1220	1177	811
Korea Republic	150	135	135	150	135	135
Uzbekistan	950	865	750	950	865	750
Thailand	760	1100	665	760	1100	665
Vietnam	750	680	550	750	680	550
Others	500	350	304	500	350	304
Total	**98725**	**90992**	**103627**	**131175**	**121392**	**126995**

Note: Figures of India is for Financial year April to March.
Source: Silk Industry in China (e-mail) ; ISC web-site update as on January,2010

Table: 2 State wise Mulberry raw Silk production (MT) during 2012 to 2017

#	State	2012-13	2013-14	2014-15	2015-16	2016-17
1	Karnataka	8219	8574	9645	9823	9571
2	Andhra Pradesh	6550	6912	6485	5086	5974
3	Telangana			101	116	119
3	Tamil Nadu	1185	1120	1602	1898	1914
4	Kerala	6	4	7	11	9
5	Maharashtra	97	122	221	274	259
6	Uttar Pradesh	157	188	236	256	265
7	Madhya Pradesh	190	195	248	257	97
8	Chhattisgarh	391	391	234	263	360
9	West Bengal	2070	2079	2500	2391	2565
10	Bihar	22	52	53	67	76
11	Jharkhand	1090	2003	1946	2284	2631
12	Odisha	104	53	98	117	125
13	Jammu & Kashmir	145	136	138	127	145
14	Himachal Pradesh	23	25	30	32	32
15	Uttarakhand	17	22	29	30	31
16	Haryana	0.13	0.13	0.3	0.6	1
17	Punjab	5	4	4	0.8	2
18	Assam & Bodoland	2068	2766	3222	3325	3811
19	Ar.Pradesh	22	15	12	37	45
20	Manipur	418	487	516	519	529
22	Meghalaya	517	644	656	857	927
23	Mizoram	40	44	50	64	76
24	Nagaland	324	606	619	631	678
25	Sikkim	3	0.20	8	6	10
26	Tripura	15	40	48	52	12
	Total	23,679	26,480	28,708	28,523	30,263

Table: 3Performance of sericulture sector

	XI Plan (2011-12)	XII Plan (2012-17)	XII Plan Achievements					
	Achievement.	Target	2012-13	2013-14	2014-15	2015-16	2016-17 (Target)	2016-17 (p)
Mulberry Plantation (Lakh ha.)	1.81	2.40	1.86	2.03	*2.20*	*2.09*	*2.27*	*2.21*
	RAW SILK PRODUCTION							
Mulberry (Bivoltine)	1,685	5,000	1984	2,559	*3,870*	*4,613*	*5,260*	*5,205*
Mulberry (Cross Breed)	16,587	18,000	16731	16,917	17,520	15,865	17,400	15,998
Sub Total (Mulberry)	18,272	23,000	18,715	19,476	21,390	20,478	22,660	21,203
	V A N Y A							
Tasar	1,590	4,562	1729	2,619	2,434	2,819	3,285	3,259
Eri	3,072	4,238	3116	4,237	4,726	5,060	5,835	5,629
Muga	126	200	119	148	158	166	220	171
Sub Total (Vanya)	4,788	9,000	4964	7,004	7,318	8,045	9,340	9,060
GRAND TOTAL	23,060	32,000	23,679	26,480	28,708	28,523	32,000	30,263

Raw Silk Imports:

The quantity and value of raw silk imported during XI Plan and during the first 4 years of XII Plan and for the year 2016-17 (P) are given below.

Year		Quantity (MT)	Value (Rs. in Crores)
XI Plan	(2011-12)	5683	1111.53
XII Plan	2012-13	4959	1238.56
	2013-14	3260	896.44
	2014-15	3489	970.82
	2015-16	3529	1006.16
	2016-17 (p)	3791	1091.85

Source: DGCIS, Kolkata. P: provisional

Exports:

The Indian silk goods are being exported to the traditional major markets like the USA and European countries and small markets of Asia Region. The silk goods export earnings decreased over the years due to global recession and reduction in demand for silk goods in western countries. The export earnings during 2016-17(P) were Rs.1, 871.01 crores. Export values of silk goods during XI Plan and during the first 4 years of XII Plan and for the year 2016-17(p) are given below:

Items	XI Plan (Rs in Cr 2011-12)	2012-13 Rs in Cr	2013-14 Rs in Cr	2014-15 Rs in Cr	2015-16 Rs in Cr	2016-17 (p) Rs in Cr
Natural Silk Yarn	19.68	21.96	36.25	25.40	30.32	9.61
Silk Fabrics	1497.97	1410.31	1455.63	1465.44	1280.60	406.22
Readymade Garments	765.83	787.15	874.00	1214.01	1078.39	1293.09
Silk Carpet	20.08	21.14	15.71	15.97	16.88	63.76
Silk Waste	49.77	62.97	99.30	109.12	89.80	98.33
Total	**2353.33**	**2,303.53**	**2480.89**	**2829.94**	**2495.99**	**1871.01**

Source: *FTSI & MSFTI, DGCIS, Kolkata* **P:** Provisional

Employment Generation:

The employment generation in the country is raised to 8.51 million persons in 2016-17(p) compared to 8.25 million persons in 2015-16, indicating a growth of 3.15%.

1.3 Scope and Limitations

Sericulture gives a large value addition chain, starting from silkworm eggs to fabrics, also extending to finished garments. Each activity in the value addition chain is very specialized and has its own specific dynamics in terms of technology, package of practices, economics, market linkages and above all, human processes. The different clusters of industry are cocoon production, silk reeling, silk twisting, handloom weaving and power loom weaving. Central Silk Board (CSB-under Ministry of Textiles, Government of India) has reported that during the year 2004-05, sericulture has provided employment to about eight million families in about 54,000 villages in the country. In total, 16,500 metric tons of raw silk has been produced comprising 14,620 metric tons of mulberry raw silk, 322 metric tons of Tasar silk, 1,448 metric tons of Eri silk and 110 metric tons of Muga silk. Apart from this, there has been an import of 7,948 tons of raw silk in to India. About 258,000 hand looms and 29,340 power looms were estimated to be in operation, producing 448 million square meters of silk fabrics, with handloom accounting for about 60 percent of the fabric production. The export earnings are 28,796 million INR (about US$640 million). Practical experiences in India and Thailand have established the fact that sericulture is scale insensitive. Poor and marginal producers have been able to earn a livelihood relatively consistently in a given average year. The drought resistant nature of mulberry has saved the lives of several thousands of small and marginal sericulture farmers in the semi-arid regions of southern India during the drought years of 2001 to 2004. During this period, though there were several cases of farmers committing suicide, none was reported of any sericulture farmer. Sericulture integrates very well with the general lifestyle of people in the rural areas. Just like a coconut tree, in sericulture also there is no waste/by-product that has no commercial value. Sericulture is highly labour intensive and the labour force comprises over 65 percent women. In the silkworm rearing activity, most often women work in their own houses and reflecting a higher level of comfort, self-worth and dignity. Similarly, the women in handloom weaving are engaged in pre-weaving as well as other preparatory processes within their own households. In silk reeling operation, family-run Charaka units use the services of all members in the family while others engage wage workers. Cottage basin units and silk twisting units hire labour, which consists of nearly 80 percent women. Reeling of silk is a semi-mechanized operation, relying largely on the skill, knowledge and judgement of the individual entrepreneur, whose earning per day is sufficient to meet the family's day-to-day requirements. Since sericulture is also a seasonal crop, it has its fair share of seasonality - lean and flush seasons. Added to this, since sericulture is an agro-based industry, it is subjected to fluctuations of nature. When there is a crisis, the poor are the most exposed. In the last decade, organizing the poor in sericulture involved in the pre-cocoon activities has paid rich dividends in reducing their weakness; whereas in post cocoon activities there is still a long way to go. Over the last four decades, Indian sericulture has grown stronger through concerted and focused efforts in Research and Development, systematic extension support and stabilized market linkages. Gains were visible in infrastructure development, capacity building of various stakeholders such as officers in the Departments of Sericulture providing extension service, R and D, and progressive farmers/producers. Efforts under the eighth, ninth, tenth, eleventh and now the ongoing 12th five year plans have brought some significant changes. The World Bank aided National Sericulture Project, support by JICA, UNDP and SDC and similar other donor agencies have contributed to the development of Indian sericulture in the last two decades. Indian Silk Fabrics are great for their existence and elegance in worldwide popular they are: Banaras Silk fabrics, Surratt, Smooth sig silks of Karnataka, Tie an Dye of Gujarat, Patola , Ikats in Orissa, the Kashmir Sig silks, Bandej pure variety fabrics, Temple silks of Kanchipuram and Tanjaur in Tamilnadu, Dharmavaram and Molkalmaru silks in Andhra Pradesh.

Implementation of Cluster Promotion Programme for Bivoltine silk:

During XII Plan, the foremost thrust to augment the import substitute silk in the country and to increase the production of BV silk to 5000 MT from the production level of 1985 MT (2012-13). To achieve the target, Central Silk Board in association with State Sericulture Departments has organized 172 Bivoltine clusters. With the joint concentrated efforts, 4613 MTs of Bivoltine raw silk has been produced against a target of 4500 MTs during 2015-16 i.e. 743 MT (19.2 %) in excess against 3870 MT produced during the year 2014-15, 63.56% (2932 MT) of the total BV raw silk production (4613 MT) is achieved through Clusters.During the year 2016-17 (up to February-2017)

4563 MT of bivoltine raw silk production has been recorded against the total bivoltine raw silk target of 5260 MT, out of which 2980 MT (65%) of Bivoltine silk has been produced by clusters.

Production during 2016-17

During 2016-17(P), the total raw silk production in the country was 30,263 MT, which is an increase of 6.1% over the production achieved during the last year and around 94.6% of the annual targeted production for the year 2016-17. The mulberry silk production was 3.5% more during 2016-17(P) over the last year. The bivoltine raw silk production achieved a record production of 5,205 MT during 2016-17(P) by registering 12.8% growth over previous year. Similarly, vanya silk, which includes Tasar, Eri and Muga raw silks, has achieved 12.6% growth during 2016-17(P) over 2015-16. The area under mulberry during 2016-17(P) is up by 6.0%

Summary

* SERICULTURE has originated from two French words, “Seris” meaning silk and “Culture” which means rearing.

- It is a natural protein fiber secreted by silkworms in form a thread about 400-1500m long, spun into a cocoon “shell” (protection to pupa inside)
- Silk – 2 proteins
- Fibroin – inner core comprising 75% of silk
- Sericin - outer gum comprising 25% of silk
- Agro-based cottage industry with very high employment potential with 60 lakh persons engaged in sericultural activities.
- Low gestation and high returns. It’s a low volume, high value crop.
- Highly women friendly occupation as 60 % of women are engaged in sericulture.
- Sericulture earns foreign exchange (>2000 crores) and silk items are exported to over 50 countries.
- Sericulture integrates very well with the general lifestyle of people in the rural areas.
- Sericulture is highly labour intensive and in all activities except silk dyeing, the labour force comprises over 65 percent women.

- Reeling of silk is a semi-mechanized operation, relying largely on the skill, Knowledge and judgment of the individual entrepreneur, whose earning per day is sufficient to meet the family's day-to-day requirements.
- Indian Silk Fabrics are great for their existence and elegance in worldwide popular they are: Banaras Silk fabrics, Surratt, Smooth sig silks of Karnataka, Tie an Dye of Gujarat, Patola, Ikats in Orissa, the Kashmir Sig silks, Bandej pure variety fabrics, Temple silks of Kanchipuram and Tanjore in Tamilnadu, Dharmavaram and Molkalmaru silks in Andhra Pradesh and Karnataka.
- More thrust is given to increase bivoltine cocoon production during XII Plan to increase the production of BV silk to 5000 MT from the production level of 1985 MT (2012-13).

Questions

Short Questions

1. What is Sericulture?
2. What are Silk Proteins?
3. Mention share of income to various sericulture groups or sectors?
4. What are the agencies contributing to develop Indian Sericulture?
5. Note some important silk fabrics in India.

Essay Questions

1. Write an essay Importance of Silk Industry?
2. Explain the Scope and limitations of silk Industry.

Ψ

UNIT 2

Cocoon quality and cocoon sorting

Structure

Learning Objectives

After studying this Unit, the student will be able to understand

- Physical and Commercial characters of cocoons
- Properties of silk and selectionraw material for reeling.
- Principals of Assessment
- The Tactile and Numerical Tests
- How to selectgood Cocoons
- How to identify and separate Defective Cocoons
- Model calculations

2.1 Introduction

The Raw silk is produced from the raw cocoons. It is, in fact, a protective shell made up of continuous and long proteinaceous silk filament spun by the ripen silkworm. The silkworm intension of spinning cocoon is to protect itself from the enemies and adverse climatic conditions, but not for human beings. Raw silk produced from cocoons used to make high value fabric. Hence the cocoons must be good in quality. For last two decades Indian silk suffered from variation in the denier which breaks during winding and weaving and thus was not preferred as a warp in the power looms, while the Chinese silk having better strength, colour and shine is used without twist for higher production efficiency. If Indian silk can be better with respective denier uniformity and strength, it can be used in powerloom as it has a better luster and dye affinity. Initially, multi end machine are not installed in any of the big factories but are used by the small reelers who can produce only a small quantity of multi-bivoltine silk. What is needed is private sector investment or producing large quantities of raw silk (C-2A grade) to feed the powerloom sector. At present the bivoltine hybrids which have promised qualitysilk as well as increased production have been exploited in this decade. All new hybrids and double hybrids now in useare producingbetter quality silk of 2A-4A grade international quality. The rearers will get the price for their product depending upon the quality of cocoons they produce.

The end product of silkworm rearing is cocoon. The rearing activities influence the production and quality of cocoon which finally reflect on the price fixation. Since silkworm rearing depends on various factors, finally the cocoons spunned inmountage are not uniform in quality. There will be double cocoons, flimsy cocoons and defective cocoons along with good cocoons. The flimsy cocoons contain very little silk and are not fit for proper reeling. Thepresence of defective or bad cocoons reduce the price of cocoon and silk quality. Further, the cocoons are basic raw material for reeling industry, so it requires a good quality cocoons. Every reeler looks for good quality cocoons. Thus, quality cocoon production plays a vital role in rearing.

Keeping in view of all the factors, after cocoon harvest, they are methodically, technically sorted before price fixation which benefits the rearer and reeler. The technical aspects related to sorting of cocoons and types of cocoons their identification, calculations are detailed in this chapter.

2.2 Physical characters of cocoons

Most of the physical characters are racial characters assigned from its parental races, which are also important to assess its quality in fixing the price.

- **Colour**

The colour of cocoon depends upon the presence of coloured pigments in the sericin layer, while cooking which will dissolve and go away along with water. Cocoon colour includes the colour and its luster. Universally there are two colours- white and yellow. White colour is further divided- pure white, grayish, white and silver white. Yellow colour is classified- golden yellow, orangish, yellow, brown yellow, greenish yellow. Efforts have been made by Research and Development wing of CSR&TI for producing genetically modified cocoons to insert gene pigment to fibroin protein for colour fastness, which were yet to be commercialized.

- **Shape**

Shape of cocoon is purely a racial character. Chinese races are round, Japanese races are dumble in shape, European are oval and Indian races are spindle in shape. The shapes of breed/hybrid may vary depends up on its parents.Spherical/oval shaped and moderately constricted cocoons are easily reelable, where as deeply constricted in the middle and cocoons with pointed ends are commercially not suitable for steady reeling.

- **Size**

Size of cocoon also a racial character but also denotes the weight of cocoons, in which all bigger cocoons will have more weight and contains more quantity of silk.Size and shape of cocoon is decided by silkworm variety and voltinism.Univoltinesare large, bivoltines are medium andmultivoltinesare small.

- **Compactness**

Compactness of cocoon is an important character that indicates the quantity of silk present in the cocoon. Compact, slightly resilient firmness of cocoon when felt by light press indicates the good commercial quality of cocoon. At present all hybrids and double hybrids are good in compactness and quality and in which thickness of shell is also good. Thickness of shell is measured by using micrometer unit 0.36-0.8 mm. Elasticity is linked to shell thickness, silk filament thickness etc. In Chinese and European variety elasticity level is higher.

- **Grain or wrinkle**

Grain or wrinkles on the cocoon are formed during spinning.Deep grained or wrinkled cocoons are not easily reelable. Cocoons with finer granulations are easy to reel. If Size of wrinkle isuniform, reelability is good, if wrinklesare coarse reelability will be poor. In Chinese variety-wrinkles are coarse but thinly spread – 'S' type. Japanese variety - Y type crisscross of filament are more wrinkles are fine anddense. European variety wrinkles feature in between Chinese/ Japanese. Force of contractions of silk proteins decide size (Coarse/fine).

2.3 Commercial characters of cocoons

- **Cocoon weight**

The weight of cocoon is one of the important commercial character considered in price fixation. The green cocoon weight will be decreased day by day until moth emerges out. All new breeds are with the higher cocoon weight when compared old breeds. If cocoons are good in weight, we can expect higher silk content.

- **Length of silk bave or filament**

This also a racial commercial character, Length of filament also indicates the cocoon quality and quantity of raw silk present.Equally important as the percentage of silk shell is measuring the length of the bave contained in the shell. The factor determines the workload, rate of production, evenness of the silk thread and the dynamometric properties of the output. The length of cocoon filament corresponds to the varieties of silkworms.

Indian multi voltine races contain 300-400 mts
Indian multi voltine hybrids 400-550 mts
Newly evolved hybrids 600-800 mts
Uni/Bi-voltine hybrids/double hybrids 1000-1500 mts

- **Denier**

Thickness of silk filament is denoted by denier (D). The denier size of outer most layer of cocoon i.e. floss layer will be higher than the inner most pelade layer. The tolerance limits for the commercial raw silk are 13/15, 20/22 denier. The denier can be calculated using the following formula

$$Denier = Total\ weight\ of\ reeled\ silk(g) \div Total\ length\ of\ silk\ filament(m) \times 9000$$

Denier is used to estimate the number of cocoons required to reel the silk of specific denier. It can be measures on denier scale also. 1 Denier filament length is 450 m that is equal to 0.005 g or 9000 mts of filament weight is equal to 1 gram is said to be one denier.

- **Reelability**

Reelability is the ratio of cocoons reeled without break and the total number of cocoons utilized. Frequent breakage results in wastage of raw material and wastage of time, hence, skill labour, quality cocoons are essential. Reelability is also defined as the fitness of cocoons for economically feasible reeling. Poor reelability causes a variety of production problems such as halts in production due to filament breakage and high degrees of waste product. Reelability is greatly affected by careful action during cocoon spinning, drying, storage, pre-processing, reeling machine efficiency and operator skill.Recent statistics show an average reelability percent for good cocoon varieties. The measured range is from 40 to 80 percent with serious deviations depending on the type of cocoon. Note that stained cocoons generally have poor reelability.

$$\text{Reelabilit y (\%)} = \frac{\text{Number of reeled cocoons}}{\text{number of ends feeding}} \text{x } 100$$

- **Shell ratio percentage**

As the entire cocoon including the pupa is sold as part of the raw material, it is essential to quantify the ratio of the weight of the silk shell versus the weight of the cocoon. This is calculated in the formula:

$$\frac{\text{Weight of the cocoon shell}}{\text{Weight of the whole cocoon}} \text{x } 100$$

This value gives a satisfactory indication of the amount of raw silk that can be reeled from a given quantity of fresh cocoons under transaction. The calculation assists in estimating the raw silk yield of the cocoon and in deriving an appropriate price for the cocoons. The percentage will change based on the breed of the silkworms, rearing and mounting conditions. Percentage rates are altered based on the age of the cocoons (see cocoon weight) as the pupa loses weight as metamorphosis continues. In newly evolved hybrids, recorded percentages are 19 to 25 percent, where male cocoons are higher than female cocoons.

- **Raw silk percentage**

This is the most important for the value of the cocoon as it has a direct impact on both the market price of cocoons and the production costs of raw silk. The normal range is 65 to 84 percent for the weight of the cocoon shell and 12 to 20 percent for the weight of the whole fresh cocoon.

- **Cocoon luster**

Colour is linked with degree of permability of cocoon shell structure to lightand light's reflection capacity.Thick shell cocoon isless lustrous (light rayscannot penetrate easily). Thin shell cocoons-good luster.Under optimum temp/RH during spinning luster is better.Air and water and permeability of cocoon shellis formed by the overlapping of silk filament crisscrosses. Inside shell there are minute air pores, size of air pore decides theaeration.

- **Water permeability**

Cocoon filament is porosity fiber possessing capillary attraction somoisturizing capacity varies wet cocoon shell and dry cocoon shell. Thisfactordecides cocoon cooking and easy reelability.Uniformity of cocoonindicates the external features of a batch of cocoons. Normal goodcocoons are suited for reeling.Unequal size, small with thin shell doublecocoons etc are rejectedwith defects affect reeling process.Uniformity of lot should be >85% Good lot <70% Bad 70- 85% ordinary lot

- **Lousiness**

Hair-like projections in the silk fibre are called Lousiness. Lousiness is more prevalent in baves produced by silkworms, which have been overfed in their fifth stage of rearing. Lousiness is found less in breeds of silkworms, which spin finer bave. Another factor promoting lousiness is mounting of over-mature larvae. This defect poses serious problems to silk fabric manufacturers, in particular those producers of smooth satin and necktie materials. When fabrics woven with these defects are dyed, it looks as if the fabric is covered with dust or is a paler shade than the rest. In fact, the protruding fibril is more transparent and has a lesser capacity to absorb dyes.

- **Composition of a whole cocoon**

The composition of the whole cocoon is defined as the cocoon shell, pupa and castoff skin shown in Table.2.Cocoon shell contain whole quantity of silk. The pupa makes up the largest portion of its weight, which is reduced after 5th day after spinning as metamorphosis proceeds and moth will emerge by leaving skin ruminants of pupa called castoff skin. Pupa is killed and desiccated during cocoon stifling to reel out continuous filament.

- **Composition of cocoon shell**

The silk filament forming the cocoon shell is composed of silk filament made of two brins (proteins) named fibroin and covered by silk gum or sericin. The amount of sericin ranges from 19 to 28 percent according to the type of cocoon.

2.4 Properties of silk:

1. Specific gravity

The bave specific gravity on average of sericin and fibroin measures from 1.32 to 1.40. Generally, the specific gravity of sericin is slightly higher than that of fibroin (See Raw silk, Table 1).

Table 1. Specific gravity and tensile strength of various fibers

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

2. Tenacity and elongation

Tenacity indicates the quantity of weight a given fiber can support before breaking. the typical tenacity of a bave is 3.6 to 4.8 g per denier (see Raw silk, Table 1). Degummed silk has greater tenacity than raw silk. Elongation defines the length to which a fiber may be stretched before breaking. Raw silk has an elongation of 18 to 23 percent of its original length. Excess moisture increases the elongation of silk, but decreases its tenacity.

3. Hygroscopic nature

Moisture content and humidity are of critical importance to commercial silk production. For instance, given 65 percent RH, the adsorption regain value is 10 percent and the associated desorption value is 11.1 percent. Currently, 11 percent is the accepted moisture regain coefficient for silk; the mercantile weight of silk is derived based on this factor.

4. Effect of light

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

5. Electrical properties

Silk is a poor conductor of electricity and accumulates a static charge from friction. This trait can render it difficult to handle in the manufacturing process. This static charge can be dissipated by high humidityof 65 percent RH at 25ºC. Based on its insulating properties, silk is used extensively for covering wire in electrical equipment.

6. Action of water

Silk is a highly absorbent fiber, which readily becomes impregnated with water. Water, however, does not permanently affect silk fiber. Silk strength decreases about 20 percent when wet and regains its original strength after drying. The fiber expands but does not dissolve when steeped in warm water. Note that the fiber will also absorb dissolved substances like salts present in water. This is the reason that special attention is given to the quality of the water utilized for reeling, washing, dyeing or finishing.

7. Effect of heat

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

8. Degradation by acids or alkali

Treatment of silk fibers with acid or alkaline substances causes hydrolysis of the peptide linkages. The degree of hydrolysis is based on the pH factor, which is at minimum between 4 and 8. Degradation of the fiber is exhibited by loss of tensile strength or change in the viscosity of the solution.Hydrochloric acid readily dissolves fibroin especially when heated – and this is used mainly in studies of hydrolysis. Hot concentrated Sulphuricacid, while rapidly dissolving and hydrolyzing fibroin, also causes sulphation tyrosine.

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

9. Proteolytic enzymes

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

10. Oxidation

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

a) at the side chains
b) at the N-terminal residues, and
c) at the peptide bonds of adjacent amino groups.

Hydrogen peroxide is absorbed by silk and is thought to form complexes with amino acid groups and peptide bonds.

General properties of silk

1. Silk is crystalline
2. Homogenous in structure
3. Hygroscopic in nature
4. Light in weight
5. Longest and strongest of all-natural fibers
6. Soft, lustrous and hygienic
7. Excellent affinity for dyes-takes colors easily
8. Does not catch fire easily/quickly as nylon or wool
9. It is elastic and has elongation of 20%
10. Has high tensile strength breaking strength is 4g per denier

Table 2. Composition of the cocoon

Weight Of	Fresh Cocoon				Dried Cocoon			
	Race A		Race B		Race A		Race B	
	Actual number (g)	Ratio (%)	Actual Number (g)	Ratio (%)	Actual Number (g)	Ratio (%)	Actual Number (g)	Ratio (%)
Cocoon	2.181	100.0	2.156	100.0	0.851	100.0	0.888	100.0
Cocoon shell	0.404	18.5	0.458	21.2	0.398	46.8	0.452	50.0
Pupa	1.765	80.9	1.684	78.1	0.441	51.8	0.422	47.5
Cast-off skin	0.012	0.6	0.014	0.7	0.012	1.4	0.014	1.6

Table 3. The composition of the cocoon shell is given below

Fibroin	**72-81 percent**
Sericin	19-28 percent
Fat and wax	0.8-1.0 percent
Colouring matter and ash	1.0-1.4 percent

Usually the sericin content of the cocoon shell is at the maximum level at the outside layer 1 becoming progressively lower at the middle layers 2 and 3 and the absolute minimum at the inside layer.Keeping in view of the above important characters for commercial purpose the defective cocoons such as undersized cocoons, malformed cocoons should be avoided due to the less content of silk. Immature cocoons stained cocoons and cocoons having mould should be avoided, as it is results in poor reelability and wastage due to the attack of fungus.

Selectionofrawmaterialfor Reeling:

Selection of cocoons as a raw material for reeling is difficult and any carelessness results in serious loss. Selective purchase of cocoons in an open market is very difficult. It is due to absence of determined standards of quality for cocoons, and standard methods of testing. In Seri culturally advanced countries cocoons are of good and uniform quality which favours test reeling, in countries like India where testing facilities are meagre the cocoon quality is estimated by application of empirical methods derived from experience in the cocoon trade and reeling industry, whichincludes preliminary enquiries, visual examination, tactile and numerical tests.

a. Preliminary enquiries

Superior quality of cocoons can be harvested by rearing quality silkworm seed. However regional and seasonal variations influence cocoon quality. Production of quality cocoons are influenced by various factors. The silk yarn i.e., the end product produced by the reeler is mainly affected by quality of cocoons. The quality and quantity of cocoons also depends on the equipment used and care during rearing and mounting.Reeler while selecting cocoons he should consider the following characters for better production of quality silk.

- Uniformity in colour, shape and size
- Built of cocoons (Compactness and hardness)
- Tightness at the ends of the cocoons
- Fully matured pupa within the cocoon
- Presence of low percentage of defective cocoons.

Lack of above characters lead to…

- Lower percentage of reelability
- Higher percentage of silk waste and low yield of silk yarn
- Increase in the renditta
- Variation in the denier affecting the quality of silk such as evenness, neatness, cleanness and increase in the number of winding breaks, poor luster and colour in the silk yarn.

b. Visual examination of cocoons:

The cocoon lots are critically observed to detect percentage of defective cocoons, uniformity in size and appearance, neatness of lot, floss quantity, maturity etc., to assess quality of individual cocoon lots before its selection for purchasing. The different sized cocoons and defective cocoons will give poor reelability and are uneconomical for reeling. Cocoons should not be too flossy. The floss adds to weight of cocoons when yielding silk for reeling. Early harvested cocoons will have immature cocoons with additional weight, which are not suitable for transaction.

2.5. Tactile and Numerical Tests

When the palm is thrust into a heap of cocoons, if it is cool and moist, it is recognized that the lot contains immature cocoons. These cocoons make muffled thudding sound instead of a rattling sound made by mature cocoons. If there is no sound, cocoons confirm to have dead pupae sticking to the shell inside. Such cocoons are not selected for reeling. The cocoons should feel firm and full when gently squeezed.

Other aspect of testing is to find out average weight of individual cocoons (actual number of cocoons per kg.). In multivoltine races cocoons harvested on fifth day count between 1000 and 1500 per kg, whereas inuni/ bivoltine races range between 600-800. Depending on the No. of cocoons/ Kg. individualweight is calculated (lower the number of cocoons indicate more silk content). Final valuation is made only after identification of unreelable and double cocoons found mixed in a lot. After then price is fixed using standard methods. The following quantities of cocoon samples are drawn for testing.

1. Fresh Cocoons

Gross weight of the lot	Wt. of sample to be drawn
2250 kg	4.5 kg
4500 kg	6.0 kg
Above 4500 kg	7.5 kg

2. Dry cocoons

Gross weight of the lot	Wt. of sample to be drawn
825 kg	1.8 kg
1650 kg	2.4 kg
Above 1650 kg	3.0 kg

The samples are weighed and kept safe for testing. The farmer delivers the cocoons to the reeler and accepts the minimum price expected for the lot. The final amount will be paid after test report. Then the cocoons are sorted into reelable and unreelable cocoons. Several types of defective cocoons are sorted. The percentages of each of these cocoons is separately calculated and recorded. Then the percentage of cocoons actually available for reeling are obtained. One third of the reelable cocoons are retained for test reeling and the remaining used for the testing of the following items.

1. Size of the cocoon (110/150 per liter)
2. Compactness
3. Grain or wrinkle
4. Weight of cocoon (150-200 gr per liter)
5. Weight of silk shell (350-550 mg/cocoon shell)
6. Percentage of silk shell (14% for multivoltine, 20% univoltine with less floss)

All the above results are recorded and reserve cocoons are subjected for test reeling. The cocoons are cooked and reeled with thread speed ranging from 150-210 m/minute. Generally, seven cocoons are taken at each end for reeling. Results are calculated and recorded on the following items.

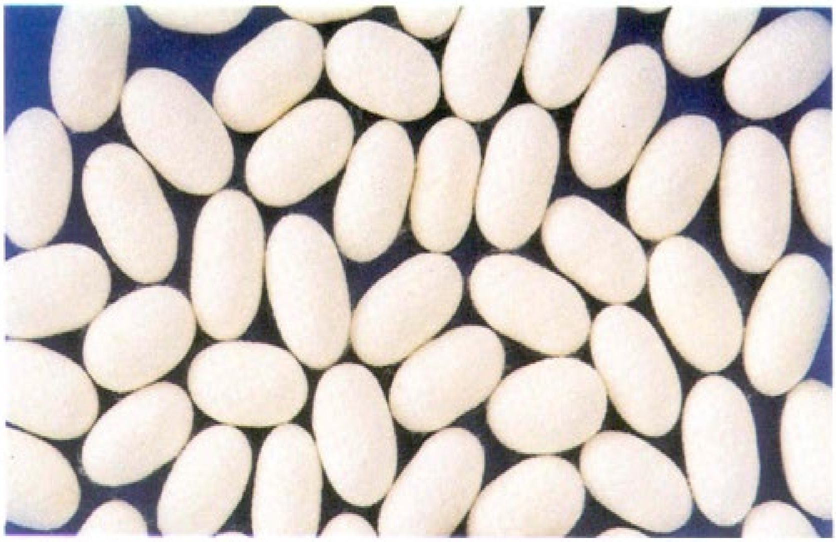
1. Average length of reelable cocoon filament
2. Reelability ratio
3. Denier of cocoon filament
4. Quantity of reelable cocoon filament
5. Raw silk percentage
6. Neatness defects

All these values help in estimating the quantity and quality of the raw silk of that particular lot. The cocoon classification is based on quality and reelability. Raw silk quality is based on uniformity in size of the thread, frequency of distribution of knots. Thus, priority is given to the length of silk bave available per casting, as longer length ensures better eveness. Denier determines the size deviation in raw silk; the higher the denier of the bave the greater will be the size deviation. For higher denier original estimation on length is suitably adjusted according to the denier size of cocoon filament for every 0.5 denier. The uniformity of size and shape of the cocoons influences the size deviation of raw silk further adjustment is made according to the excellent/first/second/third/ or fourth class. The final estimation after these adjustments is called the cocoon quality mark. On the basis of quality mark cocoons are classified into ten grades.

2.6 Good Cocoons

The cocoon quality is an important factor for sericulture. Since most of the activity in sericulture is confined to silkworm rearing, the quality cocoon production adds to good crop results the good price. However, the good quality cocoons have good market value, and these cocoons fetch good profits to the reeler also. Quality cocoon production is influenced by various factors starting from silkworm seed race, good rearing activities quality of leaf production, optimum temperature and humidity. Above all, the farmer’s concentration, interest, management, involvement in silkworm rearing is other aspects that favour good cocoon production.

Goodcocoons should have the following features.

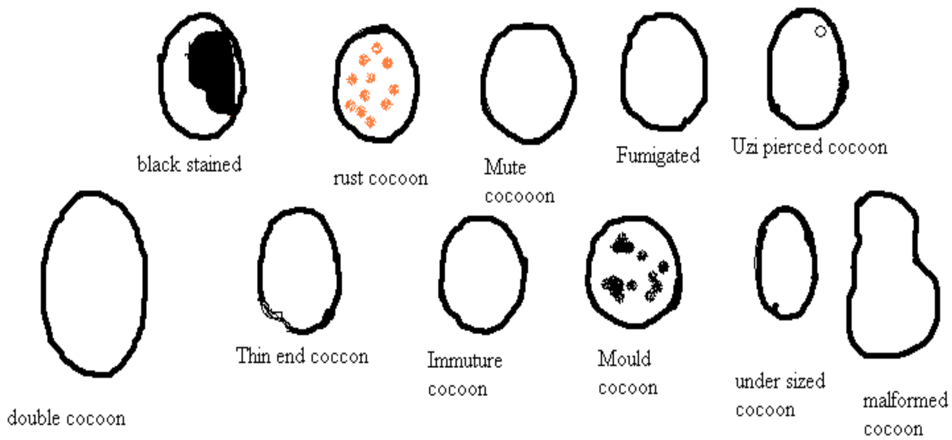


Good cocoons

1. Uniformity in colour, shape, size
2. Good hardness, wrinkles
3. Less floss
4.Tightness at the ends of the cocoon
5. Fully matured pupa within the cocoon
6. Good shell ratio, reelability, filament length, and denier
7. Presence of fewer defective cocoons
8. High silk content and better renditta value.

2.7 Defective Cocoons

The formation of defective cocoons is due to various factors like diseases, overcrowding of worms during rearing and mounting.These cocoons are not suitable for economic reeling of raw silk. The cocoonsprice is fixed by assessing the cocoon qualityjudged by calculating shell percent, filament length, reelability and the percentage of defective cocoons. Mainly the percentage of defective cocoons itself reduce the price of cocoons. Thus, these are sorted out based on its characters.Around 16 types of defective cocoons are very commonand are classified below.



Defective cocoons

a. Immature cocoons: This is a defect of untimely harvesting. These cocoons produce muffled thudding sound when shaken because the transformation of larva to pupa is incomplete.

b. Double cocoons:A double cocoon is spun by two worms, producing a filament, which does not unwind smoothly and tangles easily. As these cannot be reeled along with normal cocoons, double cocoons are used for manufacture of a coarse non-uniform, stubby yarn called "dupion". Double cocoons may be caused by crowded mounting conditions, high temperatures, high humidity and mutation of silk species.

c. stained cocoons (dead cocoons): Dead cocoons are also known as melted cocoons. In this case, the pupa is dead and sticks to the inside shell walls of the cocoon causing a stain. Melted cocoons are called ‘mutes’ because they do not make a sound when shaken. These cocoons are difficult to process and will result in silk, which is dull in colour.

d. Outside stained cocoons: These are recognized by a rusty colour spot on the cocoon shell caused by absorption of intestinal fluid/urine of the mature worm formed during mounting. Reelability is very poor in this case.

e. Pointed cocoons: This defect may happen due to improper mounting frames; these are also called scaffold pressed cocoons.

f.Malformed cocoons: These are abnormally shaped cocoons, which may arise from species variation. This defect may be due to racial characteristics and breeding problems.

g.Flimsy cocoons: Here, the shell is loosely spun in layers and has a low silk content due to death of worm and incomplete spinning. These cocoons are easily overcooked and produce waste.

h. Thin-end cocoons: One or both ends of the cocoon are very thin and risk bursting when processed. The cause of this defect may be attributed to species characteristics or improper temperature and humidity during rearing and mounting.

i. Calcified Cocoons: These cocoons contain pupa or chrysalides which are destroyed by fungus ***Botrytis bassiana (White Muscardine).***

j. Undersize cocoons: These are below normal size and contain thin silk shell formed due to improper hatching of eggs leading to unequal sized worms. These cocoons are to be separated and reeled separately.

k. Spotted cocoons: These cocoons are normal and healthy but spots or stains are found. These spots are due to various reasons. These are storing in badly ventilatedand damp store rooms, defective ventilation of cocoon conditioning chamber. Brownish black or yellow spots are due to the development of common green mold.

l. Thin shelled cocoons: These are cocoons with a thin cocoon shell layer. A large number of cocoons of this type are produced when the cocoon crop is generally poor.

m. Pierced cocoons: This happens when a moth has emerged, being eaten by beetles or in the case of the emergence of a parasite. Pierced cocoons are unfit for reeling and can be used only for hand spinning or as raw material of machine spun silk yarn.

n. Loose Knit or fragile: These cocoons are also called as straw bag. This indicates that the shell loosely woven with open spaces between groups and layers making up the shells. These cocoons contain poor silk and get water logged. These cannot be reeled.

o. Fumigated Cocoons: Some rearers adopt to fumigate formalin in mounting room to prevent the fungus which causes calcification of cocoons. The fumes of formalin make the sericin layer insoluble making imperfect for reeling.

p. Mold: Stifled or dry cocoons are generally stored for regular reeling.Mold fungus attacks on cocoons when store room is badly ventilated and damp. These cocoons are not reeled properly and results in more waste.

2.8PRINCIPLES FOR ASSESSMENT

Productivity and complete economics in sericulture is calculated onraw silk output per unit area. The cocoon quality decides the cost of rawsilk. Thiscalculation helps to fix the cocoon price that a farmer can get and creates an awareness among them to produce good quality cocoons. On the other hand, it is importantto knoweasy method of evaluating the quality of cocoons in the minimumtime given. The relationship between cocoon and shell weight is consideredto calculate the shell percentage which is linked to the ultimate rawsilk yield. The number of cocoons per kg and number of cocoons per literalso can be estimate to evaluate the quality of cocoon. Other parameterslike filament length,number of breaks, denier, raw silk percentage, reelabilitypercentage and ratio, floss percentage, number of cocoons per kg., are alsocalculated to assess the quality of cocoons.

1.Length of filament = One revolution on eprouvette = 9/8 mts. or 1.125 mts OR
400 revolutions on eprouvette =450mts.

2. Shell Ratio = Weight of the cocoon shell X 100

Weight of the whole cocoon

3. Reelability ratio = $\frac{\text{No. of cocoons reeled}}{\text{No. of feeding ends}}$ X 100

4. Denier = $\frac{\text{Total Wt. of reeled silk (g)}}{\text{Total length of reeled silk (mts.)}}$ X 9000

5. Raw Silk percentage = $\frac{\text{Weight of raw silk reeled}}{\text{Weight of cocoons used}}$ X 100

6. **Procedure for estimation of Renditta:**

The procedure has certain constants for estimating the renditta from the shell ratio which areas follows.

1. 165 for cocoons with shell ratio of 14-16%
2. 150 for cocoons with shell ratio of 17-20%
3. 133 for cocoons with shell ratio of 21-23%

The Renditta is estimated as = Constant / Shell ratio

7. Reelabilitypercentage= $\frac{\text{No of cocoons taken for reeling} - \text{Converted No. of reeling out cocoons} - \text{Converted No. of unreeled cocoons}}{\text{No. of castings} - \text{Converted no. of reeled out cocoons}}$ X100

8. No. of cocoons per Kg = $\frac{1000\ (g)}{\text{Single cocoon weight (g)}}$

9. Floss percentage = $\frac{\text{Weight of floss (from 50 shells)}}{\text{Weight of 50 cocoons}}$x100

10. Loss (%) on mountage =$\frac{\text{No. of larvae mounted} - \text{No. of cocoons harvested}}{\text{No. of larvae mounted}}$ X 100

11. After cocoon sorting the percentage of good and defective cocoons are calculated. This gives reelable cocoon percentages. All the test values help in estimating the quality or raw silk of that particular lot. The percentages of all defective cocoons and good cocoons are calculated individually by number and weight using the following formulae.

% of total defective cocoons = $\frac{\text{defective cocoons (wt.)}}{\text{Total cocoons (wt.)}}$ X 100

OR

% of total defective cocoons = $\frac{\text{defective cocoons in no.}}{\text{Total no. of cocoons}}$ X 100

% of total good cocoons = $\frac{\text{weight of good cocoons}}{\text{Weight of total cocoons}}$ X 100

OR

$$\frac{\text{Good Cocoon number}}{\text{Total no. of cocoons}} \times 100$$

2.9 MODEL PROBLEMS:

1. Shell Ratio

a. Weight of Cocoon = 1.8 gms
Weight of Shell = 0.3 gms.
$= \frac{0.3}{1.8} \times 100 = 16.6\%$

b. Weight of Cocoon = 16.6 gms.
Weight of Pupa = 1.4 gm.
Weight of shell = Cocoon weight - pupa weight
= 1.6 - 1.4 = 0.2 gm.
$= \frac{0.2}{0.6} \times 100 = 12.5\%$

c. Weight of pupa = 1.3 gm
Weight of shell = 0.3 gm
Weight of Cocoon = Weight of pupa + Weight of Shell
= 1.3 + 0.3 = 1.6 gm
$= \frac{0.3}{1.6} \times 100 = 18.75\%$

2. Filament length

Total Revolutions on epprouvette = 510
One Revolutions = 1.125 mts or 9/8 mts.
510 ----- ?
$= \frac{510 \times 1.125}{1} = 573.7$ mts.
OR one revolution = 9/8 mts
510 ---- ?
= 510 X 9/8 = 573.7 mts.

3. Denier

Weight of reeled silk = 0.25 gms.
Length of reeled silk = 573.7 mts.
= <u>0.25</u> X 9000 = 3.9

573.7

4. Raw Silk percentage

Weight of raw silk reeled = 0.25 gms.

Weight of Cocoons used = 2 gms.

$= \frac{0.25}{2} \times 100 = 12.5\ \%$

5. Reliability percentage

$\frac{10-7-1}{10-7} \times 100 = 66\%$

6.Renditta

For example, if the shell ratio of a lot is 22, then its renditta is 133/22 = 6.045

However, the defective cocoon account reduces the renditta value.For 100 cocoons are taken from renditta sample and defective cocoon number is assessed. If the percentage is less than 5% constants can be used directly or can be modified

7. Reliability percentage

$\frac{10-7-1}{10-7} \times 100 = 66\%$

8. No. of cocoons /kg $= \frac{1000}{1.8} = 555$

9. Floss percentage $= \frac{7.5\text{gms}}{90\text{ gms}} \times 100 = 8.3\ \%$

10. Loss percentage on mountage $= \frac{600-555}{600} \times 100 = 7.5\%$

11. To determine the percentage of good and defective cocoons from the given lot.

Solution

The given cocoons are sorted out into good and defective cocoons and weighed separately. They percentage is calculated individually using the above formulae.

.No.	Cocoons	No.	Weight in grams
1.	Pierced cocoons	158	140
2.	Double cocoons	22	95
3.	Pierced cocoons	16	18
4.	Malformed cocoons	10	35
5.	Urinated/stained	131	190

6.	**Flimsy cocoons**	**28**	**50**
7.	**Cut cocoons**	**0**	**0**
8.	**Good (reelable) cocoons**	**1112**	**1870**
TOTAL		**1477**	**2398**

Total Number of good cocoons = 1112
Total number of defective cocoons = 365
Total weight of good cocoons = 1870 gr.
Total weight of defective cocoons = 528 gr.

Percentage of defective cocoons by No = $\frac{365}{1477}$ X 100 = 24.71%

By weight = $\frac{528}{2398}$ X 100 = 22%

Percentage of good cocoons by No = $\frac{1112}{1477}$ X 100 = 75.28 %

By weight = $\frac{1870}{2398}$ X 100 = 77.98 %

A. Percentages of individual defective cocoons by number

1. Melted cocoons % = $\frac{119}{1477}$ X 100 = 8%
2. Double cocoons % = $\frac{22}{1477}$ X 100 = 1.48%
3. Pierced cocoons % = $\frac{16}{1477}$ X 100 = 1.08%
4. Malformed cocoons % = $\frac{10}{1477}$ X 100 = 0.67%
5. Urinated cocoons % = $\frac{131}{1477}$ X 100 = 8.86%
6. Flimsy cocoon % = $\frac{28}{1477}$ X 100 = 1.89%

Percentage of total defective cocoons = $\frac{365}{1477}$ X 100 = 24.7 %

Percentage of good cocoons = $\frac{1112}{1477}$ X 100 = 75.28%

B. Percentages of individual defective cocoons by weight

1. Melted cocoons % = $\frac{140}{2398} \times 100 = 5.8\%$
2. Double cocoons % = $\frac{95}{2398} \times 100 = 3.9\%$
3. Pierced cocoons % = $\frac{18}{2398} \times 100 = 0.7\ \%$
4. Malformed cocoons % = $\frac{35}{2398} \times 100 = 1.4\%$
5. Urinated cocoon % = $\frac{190}{2398} \times 100 = 7.9\%$
6. Flimsy cocoon % = $\frac{50}{2398} \times 100 = 2\%$

Percentage of total defective cocoons = $\frac{528}{2398} \times 100 = 22\%$

Percentage of good cocoons = $\frac{1870}{2398} \times 100 = 77.9\%$

Problems on commercial aspects of cocoons

Calculate the percentage of good and defective cocoons of a given lot which contained the following number and weight.

	No.	Weight
Melted cocoons	201	250
Double cocoons	57	75
Pierced cocoons	29	55
Malformed cocoons	37	41
Urinated/stained	185	210
Flimsy cocoons	42	30
Cut cocoons	11	22
Good cocoons	1840	2532

2.10 SUMMARY

- The quality of cocoon is very important for getting good cropreturns.
- Quality cocoons are produced by adopting modern methods of rearing and equipment, maintaining good environmental conditions.
- Quality is based on physical and commercial characters of cocoons,which influencereeling.
- Physical characters like colour, shape, size, hardness wrinkles etc. are racial characters considered to decide cocoon quality. The size indicatesthe quantity of silk filament. Fine granular cocoons are better forreeling.
- The cocoon shell has more amounts of fibroin than other substances.
- The weight of cocoon and shell are important and indicates quantity of silk that can be reeled.
- Silk is based on commercial characters. These are cocoon weight, shell ratio, filamentlength, denier, reelability, raw silk percentage, renditta etc.
- Shell ratio helps to estimate renditta and for fixing the cocoon price.
- Denier indicates size of silk bave. Renditta speakes about one-unitraw silk production from one liter of cocoons.
- The economics of sericulture is calculated on raw silk output perunit area.
- Quality of cocoon directly affects the reelability and raw silk production.
- Study of both physical and commercial characters is important for economic reeling and quality of reeled product.
- Cocoon testing includes primary enquires, visual examination, tactileand numerical tests.
- While selecting the cocoons first they are visually examined for quality assessment.
- After taking the samples defective cocoons are identified and sorted.The percentages of good defective cocoons are calculated.
- Shell ratio, filament length and denier are also calculated from the sample cocoons. Cocoons are classified based on quality and reelability.

QUESTIONS

Short Questions

1. Mention types of characters that decide quality of silk.
2. What are the contents of cocoon shell?
3. Mention some physical characters of cocoon.
4. Mention some commercial characters of cocoon.
5. What are the racial characters of cocoons?
6. What are the common colours of cocoons?
7. How do you assess hardness of cocoon?
8. What is the importance of grains?
9. What is the importance of shell weight?
10. How do you calculate shell ratio?
11. Define shell ratio.
12. How do you calculate filament length?
13. Write about denier.
14. Define renditta.
15. Define reelability.
16. How do you calculate raw silk percentage?
17. Calculate shell ratio where cocoon and pupal weights are 1.9 and 0.8gms respectively.
18. Calculate filament length with 650 rotations of epprovett.
19. Define immature cocoons.
20. What are black stained cocoons?
21. What are calcified cocoons?
22. What are mutes?
23. What are rusted cocoons?
24. Define double cocoons?
25. Define pierced cocoons.
26. What are flimsy cocoons?
27. What are defective cocoons?

28. Name some defective cocoons.

29. Write some good characters of cocoons?

II. Essay Questions

1. Write about physical characters of cocoons.

2. Write about commercial characters of cocoons.

3. How do you select raw material for reeling?

4. Write about defective cocoons.

5. Write short notes on

a) Good Cocoons b) Visual examination

6. Find out the shell ratio, filament length and denier using the valuesgiven below.

Weight of 15 cocoons is 52.5 gr., pupal wt-45 gr, No. of revolutionson eprouvette are 7650 and wt. reeled silk is 4 gr.

7. Calculate filament lengths of 12 observations using the given eprouvette values640,520,400,475,525,560,600,610,540,550,500,400.

8. Calculate shell ratio of the following cocoons

Shell weights – 0.6,0.5,0.4,0.4,0.3,0.5,0.3,0.3,0.4,0.6

Pupal weights – 3.2,4.0,3.3,2.9,3.1,2.5,3.3,4.0,4.1,3.3

9. Calculate renditta and raw silk percentage using the values givenfor 100 cocoons. Wt. 380 gr., Wt of reeled silk is 40 Gr.

10. Determine the percentage of good and defective cocoons from the given lot by using formula.

Type of cocoons	No.	Weight
Melted cocoons	201	250
Double cocoons	57	75
Pierced cocoons	29	55
Malformed cocoons	37	41
Urinated/stained	185	210

Flimsy cocoons	42	30
Cut cocoons	11	22
Good cocoons	1840	2532

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UNIT 3
Cocoon Marketing

Structure

Learning Objectives

After studying this unit, the student will be able to

- Know the importance of Cocoon Markets
- Understand the Rules and regulations of Cocoon markets
- Understand the procedure of Cocoon Price fixation

3.1 Introduction

Like all agriculture productions, cocoons the end product of mulberry cultivation and silkworm rearing also have a separate place for its marketing, which is organized and regulated by State and Central Government, where all the reelers participate in the cocoon auction for their purchase, which is called cocoon market. Farmer earns the bestprice to his cocoon lot based on its quality. The silkworm rearer always expects greater price for his cocoon lot, so can take much care on his crops and put effort to grow good quality crops of cocoons and get good price. There are two types of cocoon markets

1. Seed markets – these cocoons are used for re-productive seed production.
2. Commercial markets- these cocoons are used for only raw silk production.

In order to protect the rearer as well as the reeler and to overcome theexploitation by middle men, and to rationalize the price structure, the CentralSilk Board (CSB) and the state Government have set-up regulated cocoonmarkets and marketing federations in each state. They also have startedgovernment owned reeling units which buy all the extra cocoons at floor priceso that they do not struggle for want of buyers. Besides the state governmenthave set up centralized marketing federations and also formulated certainguide lines to be followed for cocoon transactions. Only licensed reelers are allowed to participate in well-organized systematic auctions conducted over standard prices fixed to cocoon lots based on its quality standards. Now the steps are being taken up for on-line transactions to reduce the influence of middlemen and for transparent price fixation.

3.2 Rulesand Acts

The following are the Rules and Acts framed by state Government for smooth cocoon transaction.

1. The rearer and the buyer must enroll their names as members of themarketing federation by paying a nominal membership fee.
2. All transactions are to be made only through marketing federations.
3. No private transactions are allowed.
4.The marketing officer appointed by the government is made responsible for allmarketing operations.
5. If there are no bidders, the federation itself buys them at the floor price andsends to the Government –owned reeling units.
6. The federation gets a nominal commission from both buyer and seller.As soon as the cocoon reaches the market, the rearer is issued a slip in which the quantity of his lot, address and other details are filled.

3.3 Price fixation

Marketing procedure:

In all these markets based on standard price fixed by using above principle auction is conducted between the licensed reelers in order to overcome the exploitation by middle men. The highest price in auction will be the final base price of the cocoon lot. If the farmer is not satisfied with that price, he can go for second auction or even for next day's auction. So, the farmer can sell his cocoons with his full satisfaction. The farmers also provided with facilities like advance payment for his lot, canteen and accommodation etc.,till the cocoon marketing is completed. All the payments are made through bank.

Cocoon market and auction slip

India's largest cocoon market is in Ramanagaram, a tiny townin Karnataka. Hindupur, Kadiri and Dharmavaram are major cocoon markets in Andhra Pradesh, in whichHindupur is the largest market in Andhrapradesh.

The method of floor price fixation is evolved by Central Silk Technological Research Institute (CSTRI).

For example, if the shell ratio is 22, then therenditta is 133/22 or 6.The renditta value is used for fixing the price bydividing the kakeme cost by renditta.

The **kakeme** speaks about the standardcost of cocoons required to reel one kg of raw silk. If the kakame cost is 900then the price of the lot will be…

900/6=150.

(or)

The procedure has certain constants for estimating the renditta from the shell ratio which are as follows.

1. 165 for cocoons with shell ratio of 14-16%
2. 150 for cocoons with shell ratio of 17-20%
3. 133 for cocoons with shell ratio of 21-23%

The renditta is estimated as = Constant Shell ratio

For example, if the shell ratio of a lot is 22, then its renditta is 133/22 or 6. However the defective cocoon account reduces the renditta value. For this, 100 cocoons are taken from renditta sample and defective cocoon number is assessed. If the percentage is less than 5% constants can be useddirectly or can be modified. The renditta value is used for fixing the price by dividing the kakame cost by renditta.

If the kakame value of a race is Rs. 900/-.

Then price of the lot will be 900/6 = 150

This method would be more reliable guideline than any other method. This method benefits the reeler and assures him about the quality of cocoons.

(Government changes the value from time to time)

c. Cocoons of rearer = Cocoon number per kg.

a x b Standard Cost X Standard cocoon number per kg
Cocoon price = ----------- = ---
c Cocoon number per kg (Cocoons of rearer)

3.4 Model problems

Price fixation of bivoltine cocoons:
a. Standard Cocoon number per kg = 650
b. Standard cost per kg = Rs. 200/-
c. Cocoons of rearer
Cocoons number per kg. 560

Substitute these values in the above principle…

$$= \frac{200X650}{560} = \frac{125000}{560} = 216.07$$

Cost of one kg Rs. 216.07 ps.

Price fixation of multivoltine cocoons:
a. Standard Cocoon number per kg = 1000
b. Standard cost per kg = Rs. 140/-
c. Cocoons of rearer
Cocoon number per kg. 850

Substitute these values in the principle $= \frac{140X1000}{850} = \frac{140000}{850} = 162.35$

Cost of one kg Rs. 162.35 ps.

3.5 **Summary**

- Seed markets – these cocoons are used for re-productive seed production
- Commercial markets- these cocoons are used for only raw silk production.
- CentralSilk Board (CSB) and the State Government have opened regulated cocoonmarkets and marketing federations for smooth and transparent transaction.
- The rearer and the buyer must enroll their names as members of themarketing federation by paying a nominal membership fee.
- All transactions are to be made only through marketing federations.
- No private transactions are allowed.
- The method of floor price fixation is evolved by Central sericulture Training andResearch Institute (CSTRI).
- For example, if the shell ratio is 22, then therenditta is 133/22 or 6.The renditta value is used for fixing the price

Short Answer Type Questions

1. What are the types of Markets?
2. What is the purpose of Cocoon markets?
3. What is floor price of Cocoon Market?
4. Mention the Cocoon markets in Our State?

Essay Answer Type Questions:

1. Explain about cocoon market?
2. Write an essay on Rules of the Cocoon Market?
3. Write price fixation and markets available in Karnataka and Andhra Pradesh?

4. Calculate the cocoon price by given values

a. Standard Cocoon number per kg = 1000

b. Standard cost per kg = Rs. 140/-

c. Cocoons of rearer. Cocoon number per kg. 850

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UNIT 4

Cocoon Stifling

Structure

Learning Objectives

After studying this unit, the student will be able to understand…

- The importance of Cocoon stifling
- Methods of stifling, its advantages and disadvantages.
- Storage of cocoons
- Sorting of cocoons
- De flossing
- Riddling and mixing

4.1 Introduction

The cocoons are safely stored in reeling centre after careful transporting from market. But cocoons cannot be stored directly for a long time as the live pupae transforms (10-12 days after spinning) into moth and emerges from the cocoon by piercing the shell making the cocoon unfit for reeling. Such cocoons are called pierced cocoons. The pierced cocoon is fit for spinning and not for reeling. These cocoons have lost the continuity of silk bave and become unfit for normal reeling. Thus, before storing and reeling cocoons have to be subjected to a process so as to kill the pupae. The method of killing the pupa should be done carefully without spoiling the silk quality and quantity of cocoon. The process of killing pupa inside the cocoon is called stifling. The cocoon being the important raw material for reeling has to be handled carefully, any carelessness during handling damages the cocoon quality.

After stifling of cocoons, the process of storage, de-flossing, riddling and mixing is to be done. All these processes are important in reeling industry. Every process has its advantages and disadvantages on the cocoon quality and production of raw silk.

4.2 Stifling methods

Stifling is a method of killing the pupae inside the cocoon without damaging the structure of silk shell, silk quality and quantity. There are several methods of stifling practiced in reeling industry.

1. Sun Drying
2. Steam Stifling
3. Hot air Drying

4.2.1 Sun Drying

It is a method of killing and drying the pupae by prolonged exposure of freshly harvested cocoons to hot sun. The cocoons after sun drying can be preserved for a longer duration without any problem. Immediately after harvest of cocoons they are thinly spread on mats or trays and kept under the hot sun rays. Care should be taken to protect from ants and other predators. This process is carried from sunrise to sunset for several days till the pupae are killed and completely dried. Dried cocoons are very light and make rattling sound when shaken.

Advantages:

- It is simple, easy and cheapest method
- Drying is even / uniform

Fig 4.1 Sun drying of cocoons

Disadvantages:

- Increases wastage of silk during reeling.
- It is bulky and wasteful in space and labor.
- Cocoons get dust and dirt during the process.
- It is not suitable for modern reeling
- It is possible only in bright and hot sunny days.
- Silk is very sensitive to sunlight and prolonged exposure affects the strength of the bave impairing reelability and results in poor quality silk
- **To overcome above disadvantages black cloth is covered on cocoons to filter scorching rays and to absorb only heat for stifling.Dust and dirt also be prevented.**

4.2.2 Steam Stifling.

In this process fresh cocoons are exposed to hot wet steam, for a required period. There are several methods of steam stifling. Out of those methods' basket steaming and chamber steaming are in practice, because these methods are quite suitable to small scale reeling ventures.

A. Basket Steaming

This method of steaming is followed by small scale reelers. It is very simple and 10-15 kg of fresh cocoons can be stifled easily. First of all, defective cocoons are separated from the cocoon lot. The bamboo basket used for this method closely woven on sides and bottom is loosely woven to allow steam to pass through easily. About 10-15kg of cocoons loosely filled in basket, wet gunny cloth is stretched over the top of the basket and tied at the sides leaving the bottom free. Then the basket is placed over the mouth of a vessel in which water is boiled. The hot steam vapour coming from the vessel enters and fills the basket which kills the pupae in an about half-an-hour. Steaming is stopped when dense fumes of steam starts coming out of the wet gunny cloth covered on basket. Further it emits a smell peculiar to the freshly steamed cocoons

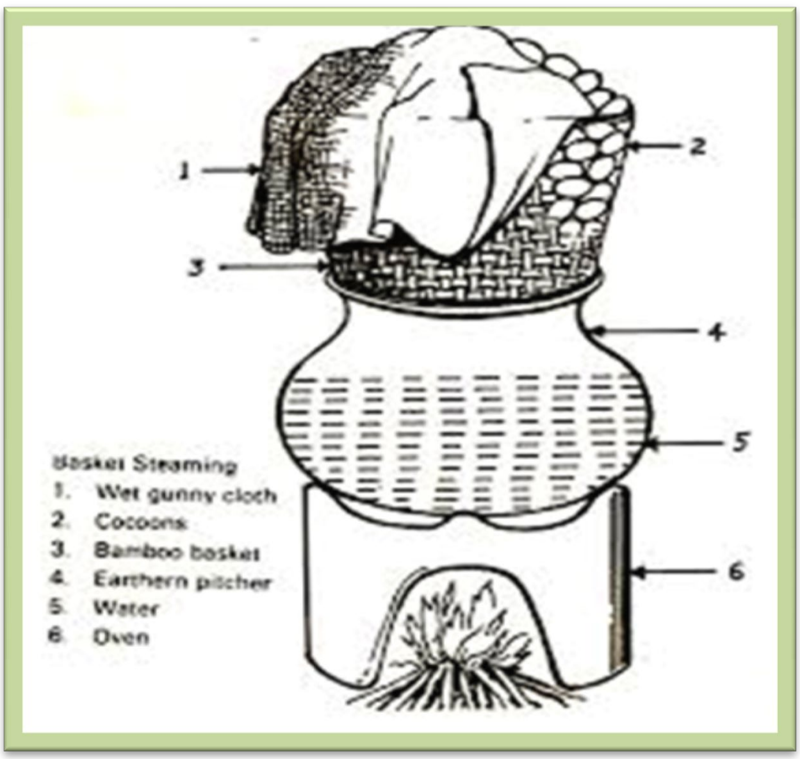

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Fig 4.2. Basket steaming

When the open palm is lightly placed on the freshly steamed cocoons they are hot, damp, slimy and sticky and the cocoons yield soft and wet nature due to steaming. Which indicate proper stifling, otherwise the steaming is continued for some more time. After stifling for 15-20 min cocoons are dried for several hours under shade as wet cocoons cannot be stored immediately because they are easily affected by fungal pathogens and freshly steamed cocoons are not at all suitable for immediate reeling. When such cocoons are reeled the silk bave comes off in lumps and spoil the quality of silk leading to silk waste. The above process of drying cocoons is called seasoning, which is an important process before reeling. which can make cocoons fit for reeling. The drying is continued till the weight of cocoons is reduced to one third of original weight of fresh cocoons. If steamed cocoons are required to be stored for a long-time, they are thinly spread in trays and kept in well ventilated rooms. However, this long storage required additional labour for frequent turning of the cocoons to ensure uniform drying and also to prevent fungus attack.

B. Barrel Steaming:

This method is similar to basket steaming. But here instead of bamboo basket, a metal barrel is used for steaming. In this a convenient size barrel is fixed over an oven. The barrel is provided with a porous platform at the just above bottom on which cocoons are placed for stifling. Below this platform water is filled for boiling. The mouth of barrel is provided with a closefitting lid to prevent the escaping of steam, when steaming is in progress (Fig. 4.3).

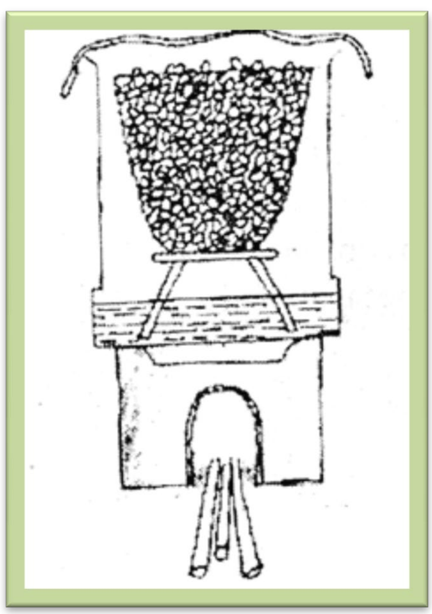


Fig. 4.3. Barrel Steaming

The barrel is filled with 15-20 kg of green or live cocoons on the platform and barrel lid securely closed. Due to continuous fire the water boils and produce steam vapour and builds up pressure in the barrel, moves through porous platform and stifles the cocoons in 10-15 minutes. This method of stifling is faster than basket steaming.

C. Chamber Steaming:

This method is suitable for stifling large quantities of cocoons. Chamber steaming is useful for big reeling centers, where large quantities of cocoons are required per day. There are two types steaming chambers, one fixed shelf type and another is movable shelf type. Chambers are constructed for steaming the cocoons. These chambers are internally provided with perforated steam pipes which are connected to the steam boiler by steam supply pipe. (Fig. 4.3).

The trays of the shelf are filled with cocoons and the chamber's door is securely closed. The steam under pressure is released into the chamber by opening the steam valve. The steaming is continued for a required time then the steam valve is closed. Then the cocoon trays are removed for airing. In fixed shelf type steaming, a lot of time is wasted in loading and unloading of coons in trays. The wastage of time could be reduced by using movable trolley type chamber with additional set of trolleys and trays. (Fig. 4.4).

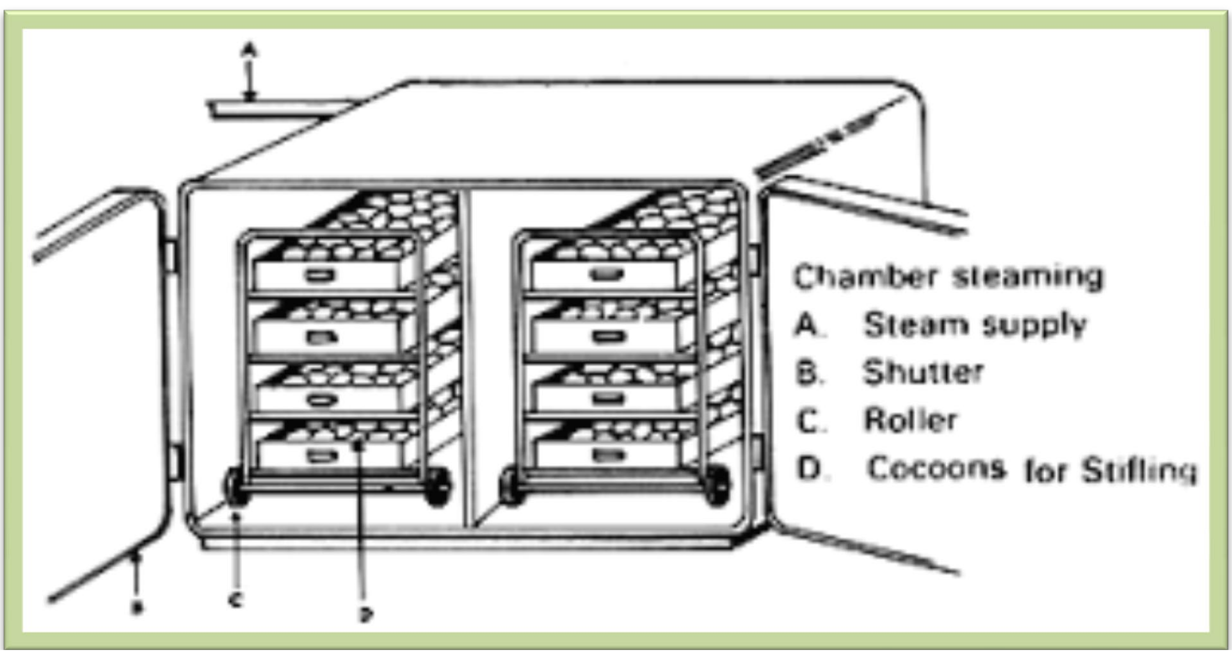


Fig.4.4. Chamber Steaming with movable trolleys

Advantages of Steam Stifling:

- Large quantity of cocoons can be stifled, except for basket and barrel method where 15-20 kg cocoons are stifled.
- Stifling time is shortened in barrel and chamber steaming methods compared to basket steaming.

Disadvantages:

- It kills the pupa inside and drying is not possible.
- The moisture content makes the pupa fragile and weak. When such cocoons are stored in thick layers, the pupae of lower layers are crushed under the weight of cocoons above. Thus, leading to the leakage of body fluids and spoiling the silk of cocoons.
- Steamed cocoons require lot of shaded space for aeration.
- More labour is required for giving frequent turnings of stored cocoons so as to prevent attack of fungus and to ensure uniform and quick drying.
- Humidity of store increases due to natural exploration of the moisture from the pupae resulting in mould formation and lead to decomposition and stain the shell and damage the reeling properties of the cocoons.
- Wet hot steam also denatures sericin, affecting the reeling resulting in silk wastage and quality of reeled silk.
- Steamed cocoons cannot be reeled immediately after steaming because the sericin will be wet, hot swollen and soft.
- Steam stifled cocoons should be reeled within a period of 8-10 days as the sericin is wet and increase the waste of silk.

4.2.3 Hot Air Drying:

The objective of hot air drying is to kill the pupae and also drying the cocoons either fully or partially to a desired degree of dryness. This type of conditioning is carried in special chambers and the method of stifling is the most scientific.

A. **Old type hot air dyer**:

There are many types of hot airdrying systems in different countries, which have evolved from the older type of drier. The basic requirements of a hot air dryer are

1. Chamber for keeping the fresh cocoons to be dried.
2. Fan or blower to supply a steady current of air to pass through the different layers of cocoons and carry on the process of desiccation during the drying process.
3. Heating equipment and thermometric regulation of temperature in all parts of the chamber.
4. Chamber is provided with adequate ventilation for rapid removal of products of desiccation i.e., moisture, volatile gases (ammonia).

In this method the pupae become dry and the cocoon weight is reduced to about 1/3 of the original weight (complete desiccation). By limiting the loss in weight to about 40% of the fresh cocoon weight, the cocoon stifling turnover can be increased to twofold (partial desiccation). Limiting of loss in weight to only 20% the turnover can be increased up to four times compared to complete desiccation. The operation can be carried without any wastage of time between loading and unloading of cocoons. Further the cocoon movement in the chamber is directed opposite to the current ofhot air blown into the chamber. This process of movement helps in complete desiccation. Proper drying of cocoons enables a high percentage of reelability and high grade of raw silk. The degree of drying depends on the following properties of cocoons.

1. The racial characters.
2. The seasonal variations.
3. Shell ratio.
4. Quantity of cocoons to be handled at a time.
5. The moisture contents.
6. The speed of air into the chamber.
7. Rate of evaporation of moisture from the pupae.
8. The temperature and humidity conditions inside the chamber.
9. Duration of drying.

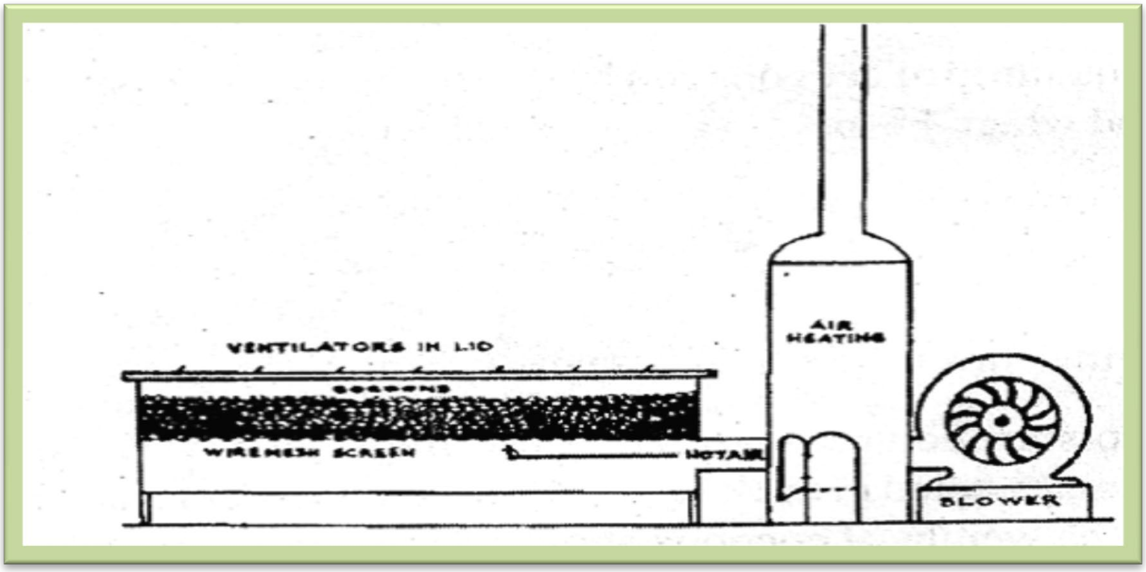


Fig.4.5. Old Method of Cocoon Drying Equipment

B. Modern hot Air dryer

There are many kinds of hot air conditioning chambers of which shelf carrier type and conveyer type are common.

Shelf carrier type: It consists of movable trolleys containing trays in a chamber, which can be removed and pushed in during conditioning. The trays are filled with cocoons and are dried by the flow of hot air current blown from blower fixed at the bottom or top of the chamber and automatic temperature control unit maintains required temperature for required duration. By maintaining additional trolleys cocoon stifling is continued without break which can feed large scale reeling industry.

Conveyor type: This method is quite suitable for large scale semi-automatic or automatic reeling units. In this there are eight conveyer platforms, one in each chamber. They are arranged one below the other. The conveyers are usually 18 m long, move at a speed of 18 to 24 meters per hour during operation. Therefore, the total length traveled by cocoons in the process is around 144m and time taken for full conditioning is about six to eight hours depending upon the speed of conveyer platform or belts. The equipment is provided with special arrangement to control the air current to diffuse the hot air in the several layers of cocoons in the conveyer belt.

This ensures uniform and efficient drying of the cocoons. The processing capacity of this method is about 8000kg of green cocoons per day. The temperatures maintained in first five chambers are in the following descending order where drying occurs progressively.

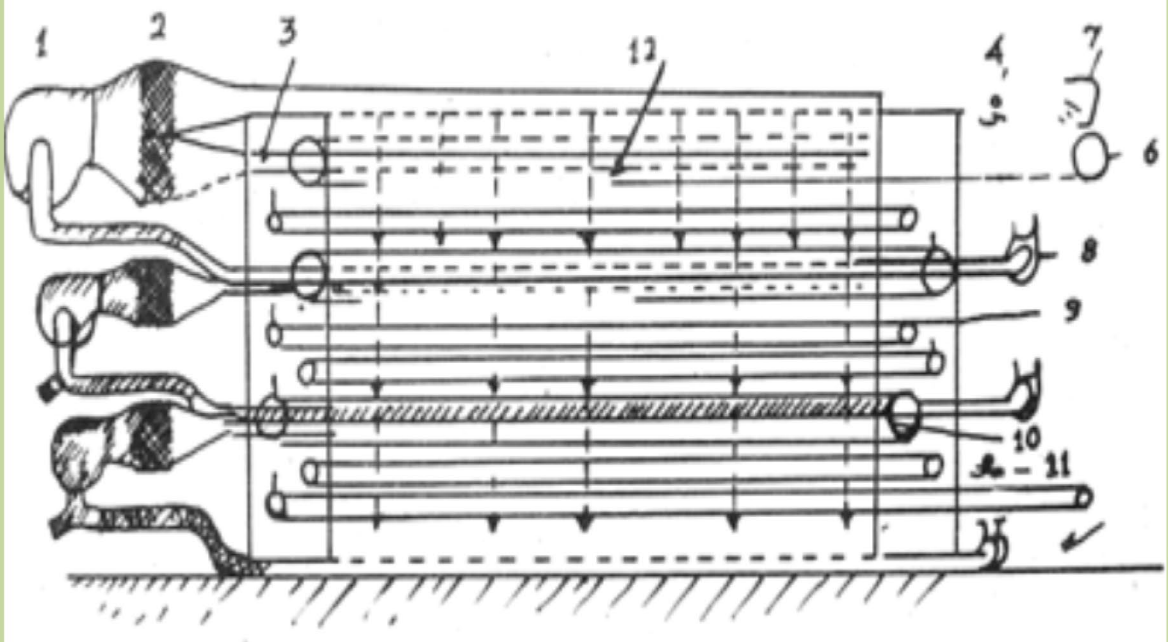
I chamber - 93°C to 95°C
II chamber - 84°C to 85°C
III chamber - 80°C to 82°C
IV chamber - 77°C to 80°C
V chamber - 74°C to 75°C
VI chamber - 65°C
VII chamber - 60°C
VIII chamber - 54°C

Here gradual cooling of cocoons along with drying takes places and method of the operations are done mechanically. The equipment consists of a rectangular chamber which internally consists of compartments. It has an exhaust pipe and formal inlet. The hot air flow continuously and fans are provided in order to check stagnation of moist hot air. This helps to obtain uniform temperature. It is also provided with a temperature regulation mechanism

Advantages:

- Killing of pupae inside cocoon or Stifling and uniform drying are achieved at once in one system.
- Cocoon characters, quality is protected
- It is most scientific.
- Raw silk recovery is more and wastage is very little.
- Drying capacity is more.

Many methods other than steam and hot air have also been tried for killing the pupae. They are use of infrared rays; one step drying cellar method; cold air killing; Radio wave killing and poisonous gases. But the hot air drying is more advanced, best suitable and environmental friendly method.



"Yamoto" hot air drying machine

1.Blower 2. Heater 3. Hot Air Duct into Chamber 4. Air Exhaust from chamber 5. Air inlet 6. Conveyer 7. Automatic cocoon feeder 8. Exhaust fan 9. Screen type cocoon conveyer 10. Chamber partition board 11. Cocoon cooler 12. Thermo indicator

. Courtecy: Dr.Mahesha, UoM, Mysuru

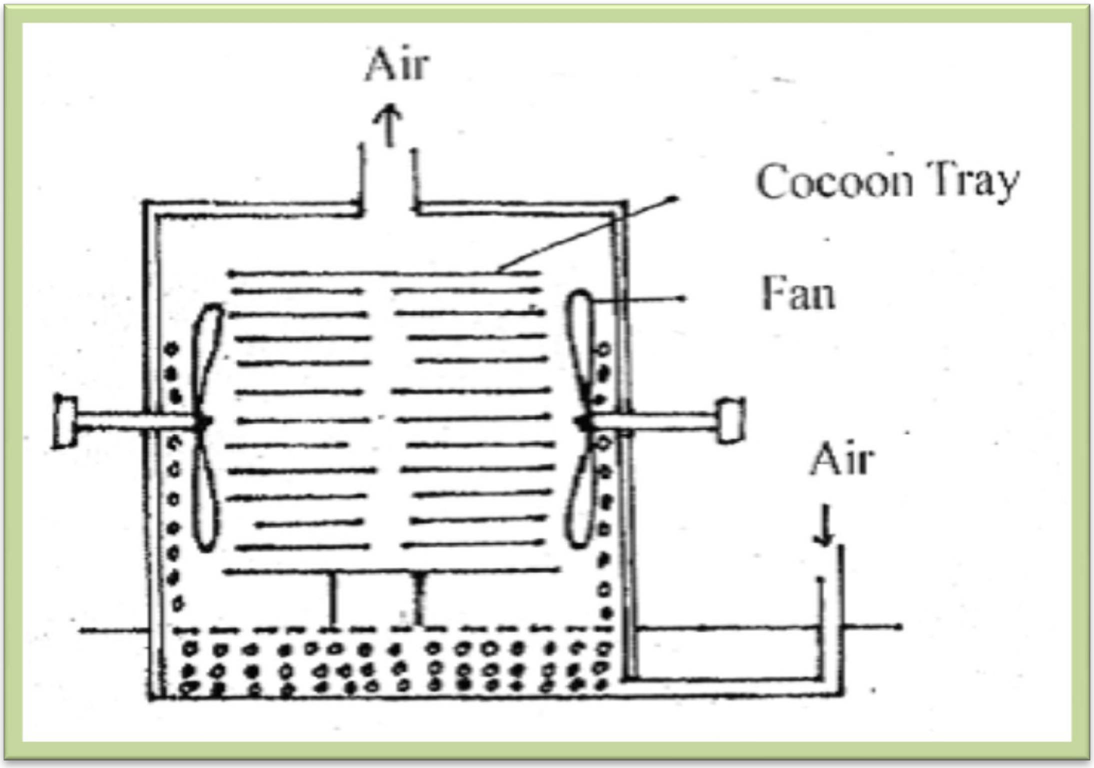


Fig 4.6 Modern Hot Air Dryer Shelf carrier type

4.3 UshnaKoti

The 'Ushnakoti'-a hot air cocoon stifling chamber is having the dimension of 14' length, 10' width and 10' height. This is constructed over a foundation of cement-concrete bed. The super structure consists of burnt brick masonry and mud joints. Its outside walls are plastered with cement for protection from rain and inside walls with mud for insulation. Roofing is made with grooved asbestos sheet on wooden frame. It has eight ventilators at the bottom and four at the top of size 9" x6" with adjustable window pan made of plain asbestos sheet supported by wooden framings. One wooden door of size 6' x 3' is fixed in front of the chamber. Four glass windows of size 6" x 6" are fixed on all four walls of the chamber to record the temperature at a height of about 6' f ft from the bottom. ln left corner of the front side, one oven of size 1'x 1' is constructed on the ground keeping the fuel feeding part outside. The oven is made of reflector bricks to prevent heat loss. This is connected to outlet gas pipes running all around the chamber and finally connected to the chimney for smokeless. This oven is suitable for feeding firewood as fuel. This can be suitably modified for other fuels also. The floor is made of soil with 5" thick sand bed over it.

Arrangement of cocoons for stifling:

The cocoons are filled in perforated trays of size 2'x2', each has a capacity to accommodate 2 to 2.5 kg of green cocoons. These trays are placed one above the other in parallel rows on specially designed cocoon racks of size 4'2" x2' x7 ' made of iron. The above cocoon rack consists of 20 parallel rows which can accommodate 40 perforated aluminium trays, overall 80 to 100 kg green cocoons can be easily accommodated in one rack. The chamber can conveniently hold three such racks. Thus, 250 to 300 kgs of green cocoons can be stifled per batch in this chamber.

Working principle:

The hot flue gas produced inside the oven is circulated through the flue-gas pipes all around inside the chamber at different angles. As the flue gas pipe is thin, the heat energy from the flue gas is easily released inside the room and heats up the surrounding air. The pupae inside the cocoons are first killed by hot air and start drying by evaporation of pupal body fluid. The moist air expel out of the chamber through the top ventilators. The bottom ventilators are responsible for controlling the air-flow inside the chamber and create an automatic air draft.

Operational procedure:

1. The green cocoons which are to be stifled are first filled in the aluminium trays and kept ready outside the chamber for loading.
2. Now the fire is set on in the oven and tested for any smoke leakage.
3. After testing, the trays with the cocoons are placed on the racks inside the chamber.
4. After loading of cocoons the door is closed and care is taken to avoid any heat leakage.
5. Fire is continued even after the closure of the door. The temperature inside the chamber at different places is recorded with the help of dial thermometers.
6. When temperature reaches 100°C, the time is recorded. Fire is continued further for at least four hours to get 30 to 40% weight loss, maintaining around 100° C temperature.
7. During this period both bottom and top ventilators are regulated for expelling the moist air formed inside the chamber, due to evaporation of pupal body fluid.
8. After four hours of stifling, the fire is stopped and temperature is allowed to come down.

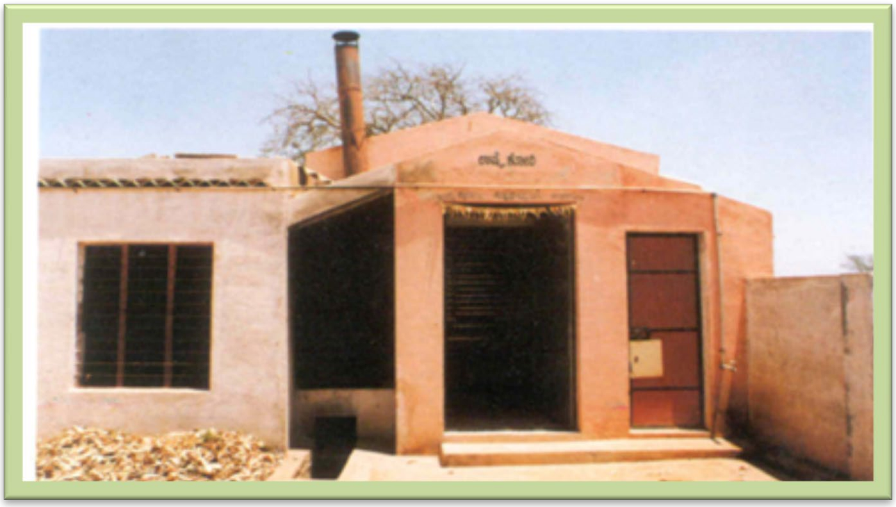


Fig 4.7 Ushnakoti

Advantages:

1. Construction is simple and cost of investment is less.
2. Suitable for village reelers on co-operative basis.
3. Electric power is not required.
4. Suitable for mulberry and non-mulberry cocoons.
5. All kinds of fuels can be used.
6. Stifling cost per kg of cocoons is lowest.
7. 250 to 300 kg of cocoons can be stifled at a time.

4.4. Sorting of cocoons

The defective cocoons are sorted out by the rearer before taking the cocoon crop to market. Even then the cocoons are again sorted before reeling. Further cocoon may become defective in the process of transporting, stifling, storing etc. Therefore, second sorting is a must before reeling, to produce good, quality raw silk. Defective cocoons such as double, stained, crushed, flimsy, malformed, fluffy, insect damaged, mould attacked are found in small quantities which are removed and rejected, for production of highgrade raw silk. The sorters sit around the tables, on which cocoons are spread. The sorters pick out defective and double cocoons separately. The double cocoons are used for dupion silk production. In Indian filatures, instead of tables with low partitions, convenient sized bamboo trays or mats are used for keeping the cocoons for sorting.

Rejections are put in separate baskets. However this method of sorting is not scientific because it does not detect defects that may be inside the cocoon shell.

CSR&TI developed the cocoon sorting table on which by passing the cocoon over ground-glass plates fixed on table and illuminated from below glass will clearly shows the defective cocoons and its separation made easy.

There are two methods of sorting.

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

Immediately after the cocoons are received in the cocoon stores, flimsy, stained and method cocoons are picked out and separated. These can be easily seen in the cocoon lot. If these are not sorted out they will spoil the good cocoons by staining and increase the number of defective cocoons. After stifling and drying the cocoons are subjected to sorting and later grading, the skilled workers who are the called sorters are entrusted with the sorting. If the storing is improper, it results in high percentage of defective cocoons which are unfit for reeling.

Fig 4.8 Cocoon sorting table

4.5. Storage of cocoons

It is one of the important aspects of reeling. It is a problem when stifled cocoons are to be stored for a long time. Cocoons must be completely dried before storing. Even completely dried cocoons are also sometimes damaged by mould attack if the storage room is not kept dry.

Other problem in storing is pests. Dermestid beetle, rats, squirrel and other pest attack which feeds on the fat content of the dried pupae for which it cuts the silk shell and damages the cocoons. The beetle is attracted by the smell of putrefying pupae. The colour of the cocoon is also affected if not stored properly. Therefore, after stifling dried cocoons are to be stored in a store house which is protected from pests, predators and is moisture proof. To protect the cocoons from fungal attack, the inside temperature and relative humidity of the store need to be maintained at 27°C to 30°C with 60-70% respectively. The following tips are adopted for safe storing.

- All the spotted and stained cocoons are collected from healthy cocoons and thrown away.
- Waste cocoons and silk are stored far away from the store room for better control of pests.
- Store house should be protected from direct sunlight but proper aeration is essential.
- Walls and ceiling should be disinfected with 2% formalin.
- If any insects are found in stored cocoons all the cocoons are passed through hot air at 60°-70°C for some time to kill the insect pest population.
- Cocoons should always be kept in thin layers on trays and kept open for natural evaporation.

Preventive measures to control moulds:

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

4.6 De-flossing

De- flossing is removal of silk waste present on the surface of cocoon shell. The cocoon with floss disturbs the mechanical processes results in slowing the reeling operation, and increases wastage of material, labour and time. Thus, the superficial floss must be removed. The multivoltine cocoons are generally more flossy and medium firmness in build compared to uni and bivoltine cocoons. Such cocoons are de-flossed by the sorters by peeling the floss from the cocoon with the hand or iron rod of 60-65 cm long. This process may be laborious but the obvious advantage is that required quantity of floss is removed from the cocoons. One end of the rod is bent into the shape of a handle. The handle of the rod is held in the toes of the sorter's foot and long end of the rod is thrust a little below the surface layers of cocoon heap. When sorter turns the handle the iron rod collects round itself the floss. A simple hand or power operated de-flossing machine is developed by CSR&TI, which is useful for medium scale reeling industry.

4.7 Riddling

This process helps to separate the cocoons according to their sizes. The de-flossed cocoons when fed to riddling machine, they are separated and collected as large, medium and small sizes. This process is more useful to the reeler since only uniform size cocoons offer scope for production of high-grade silk. The cocoons can be separated using simple sieves or mechanical operations. There are appliances which combine de-flossing and riddling operations. They consist of two distinct but connected parts. The first part of machine de-flosses the cocoons while second part riddles the cocoons.

4.8 Mixing

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

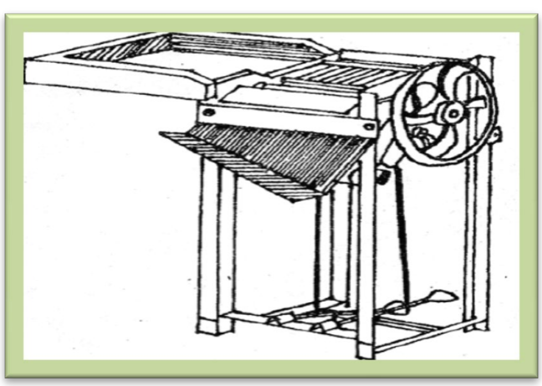
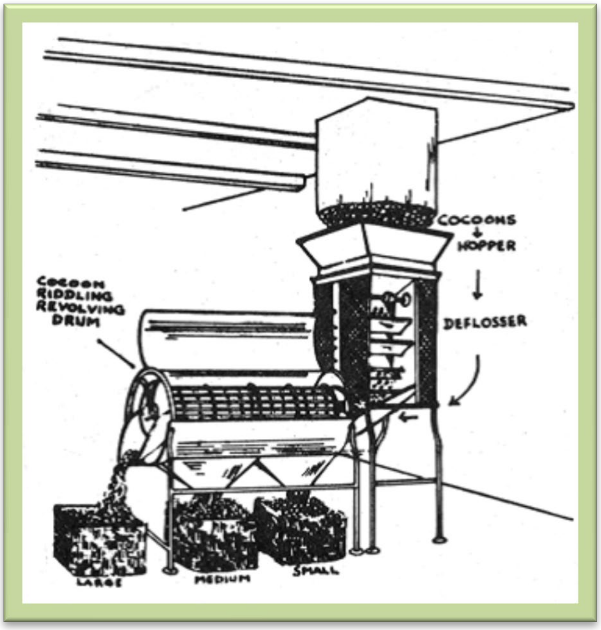


Fig. 5.9 De-flossing machine



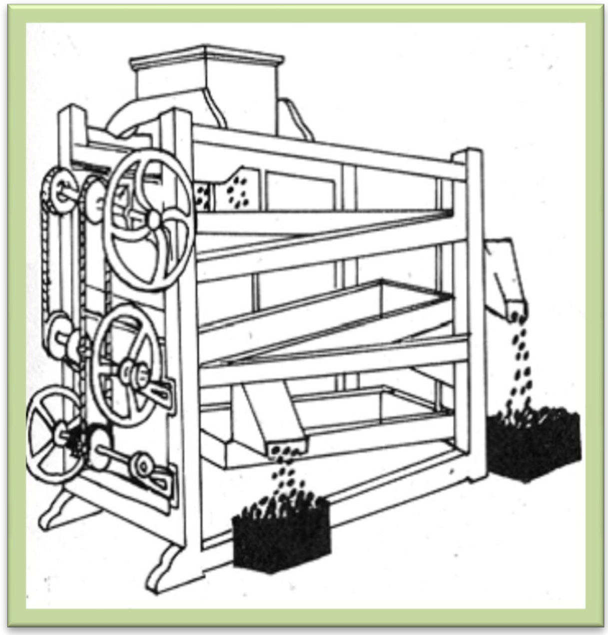


Fig. 5.10 Cocoon Ridding Machine

Fig. 5.11 Combined Cocoon De-flossing and Riddling Machine

4.9 Summary

- Stifling is the method of killing the pupae without damaging shell of the cocoon.
- There are sun, steam and hot air drying methods.
- Sun drying may be cheap but takes longer duration and not suitable for modern reeling.
- In steam stifling the cocoons are exposed to hot wet steam.
- There are several methods of steam stifling such as basket steaming, barrel, chamber, etc.
- When the cocoons are stifled it emits a peculiar smell.
- Freshly steamed cocoons are hot, damp, slimy and sticky and yield to slight pressure and Steamed cocoons are kept in shade for air as they are not suitable for immediate reeling.
- The disadvantage of steam stifling is that it kills the pupae but does not dry it.
- Hot air drying is aimed at killing and drying the pupae.

- The commonly used methods of hot air drying are shelf carrier and conveyor type methods.
- Hot air drying method is most scientific where cocoon characters and qualities are protected.
- Care should be taken while storing stifled cocoons against beetle pest, rats and moulds by maintaining proper ventilation and 70% humidity.
- Sorting of cocoons helps to eliminate defective cocoons.
- De-flossing and riddling operations before reeling improves the qualities of the silk.

I. Short Answer Type Questions:

1. Define stifling.
2. What are the advantages of sun drying?
3. Define steam stifling?
4. What is seasoning of cocoons?
5. What are the main disadvantages of steam stifling?
6. What is the objective of hot air drying?
7. What are the advantages of Ushnakoti.
8. What are the problems of storing of cocoons?
9. What is sorting of cocoons?
10. Define de-flossing.
11. Define riddling.
12. What is cocoon mixing?

II. Essay Answer Type Questions:

1. What is the importance of stifling? Explain the methods of basket steam stifling.
2. Explain Hot Air drying?
3. Detail about chamber steaming of cocoons.
4. Write in detail about Ushnakoti.
4. How do you store stifled cocoons?
5. Write short notes on a) Cocoon Mixing b) Sun Drying
6. Write short notes on a) Riddling b) Barrel Steaming
7. How do sorting, de-flossing, riddling, improves the quality of reeled silk?

Ψ

UNIT 5

Cocoon Cooking and Brushing

Structure

5.1 Introduction

5.2 Cooking and methods of cooking

5.3 Brushing and methods of Brushing

5.4 Summary

Learning Objectives

After studying this chapter student will be able to know

- Importance of reeling water
- The importance of cocoon cooking
- Cooking and methods of cooking
- Brushing and methods of Brushing

5.1 Introduction

The silkworm cocoon is a ball of closely woven silk filament or bave, one end is inside and the other outside. The filament is continuous and consists of fibroin in the middle layer, held fast by the natural gum sericin outer layer. It is necessary to soften the gum by putting the cocoon in hot water before unwinding the filament through process of reeling. Reeling is not an easy job as the baves are bound by a hard gum like protein known as sericin. Hence the sericin has to be melted so that fibroin which is the main constituent of the cocoon filament is liberated free. The process of softening sericin gum and loosening filament layers of cocoon by boiling in water is popularly known as cocoon cooking or boiling. Further cocoon cooking process also helps in brushing the entangled floss layer of the cocoon from the true end of reelable filament. The degree of cooking depends up on the quality of cocoons. Thus, the details of sericin protein, properties of silk, cooking process, its methods and brushing process its methods are detailed in this chapter.

Solubility of Sericin

Sericin protein contains amino acids like serine, threonine, aspartic acid, glutamic acid and large amounts of lysine and argenine. Sericin contains three layers i.e. outer layer or sericin-I which is easily soluble in water, middle layer or sericin-II which is also soluble but containing traces of crystals of sericin. The inner or sericin-III is not soluble in water easily. Because of the above properties the cocoons are to be cooked effectively with minimum waste of silk by a skilled operator. The chemical characteristics of fibroin and sericin differ due to the differences in the amino acid composition. Wetting and softening of sericin which binds the baves in the cocoon is carried by subjecting the cocoons to the action of hot water. The cocoon shell is naturally water repellant. As regards to sericin, it is less soluble in innermost layers than in the middle or outer layers. Solubility of Sericin (Murayama, 1954) is estimated below.

Cocoon Layers	Total Sericin (%)	% of Solubility
1	36	9.5
2	21	5.7
3	20	3.8
4	19	3.2
5	21	1.7

The above-mentioned peculiar characters of the cocoon create problems in cooking all the layers of the shell uniformly. Further cocoons with high percentage of silk, thick shell and fine bave, hardened shell due to prolonged exposure to high temperature, become more problematic in reeling. Therefore, care should be taken during cooking.

5.2 Cooking methods

The cooking process is done for softening the sericin at the same time to facilitate easy unwinding of the silk filament. The little percentage of sericin should be retained with the fibroin to facilitate attachment of filaments in the thread formation. In cooking process 7 to 8 per cent of sericin is dissolved. Proper cooking of cocoons for making them easily reelable with minimum waste of silk material is very important. This depends upon the nature of the cocoon, construction of the shell and storage time and condition. In order to cook the cocoons properly there are different types of systems of cooking.

1. Top reeling or floating system

2. Sunken system

In top reeling the cocoon shell becomes wet and impermeable to water and float in water when the cooked cocoons are put in to the reeling basin. In sunken system the shell is cooked and the process fills the cocoon with 97-98 per cent water and makes the cocoon heavy and which sink in the reeling water. The top reeling is an old method and still used in low cost reeling like country charka, while sunken reeling is a latest method and used all advanced reeling machines.

1. Top Reeling

There are two methods i.e. A) Open pan, B) Three pan type, which are detailed under;

A. Open Pan Type:

In this method cooking is carried in simple pans or vessels of copper or earthen pots. The vessel is filled with water and heated by firewood, charcoal or electric heater. When the water starts to boil, handful of cocoons is put into water and kept immersed for 3-4 minutes using perforated ladle. When the cocoon turns into translucent, dull in colour, soapy to touch and when filaments come off on pulling indicates proper cooking are taken out for reeling. The temperature of water is maintained at 90-95°C during cooking. The bunch of cocoons with the ends are taken on the ladle and transferred to the reeling basin. It is easy method but defective because of the reasons detailed below (Fig 5.1).

Disadvantages:

1. Only outer layer is cooked but not the inner layer.
2. If cooking is continued for a long time two inner layers are properly cooked but outer layer gets over cooked. Due to this the sericin is softened and causes the filaments to come off in lumps.
3. Cohesion, luster and cleanness of reeled silk is affected very badly.
4. If the cocoons are removed for reeling soon the outer layers are cooked reeling becomes difficult when the process reach the middle and inner layer.

5. Since cooking and brushing are carried in same basin, the dirt and material released from cocoon make the water dirty. The operator has to change the water regularly. This adds to consumption of water and heating expenses, which leads to increase in cost of production.
6. Because of small size of the basin only limited quantity of cocoons are cooked which limits the reeling process. If the cooking basins are increased the expenditure increases.

Advantages:

1. The advantage of this method is that the cooking process is carried in front of skilled reeler, who can instruct and influence the cooker for better reeling process.
2. Its quite suitable to low cost reeling methods.

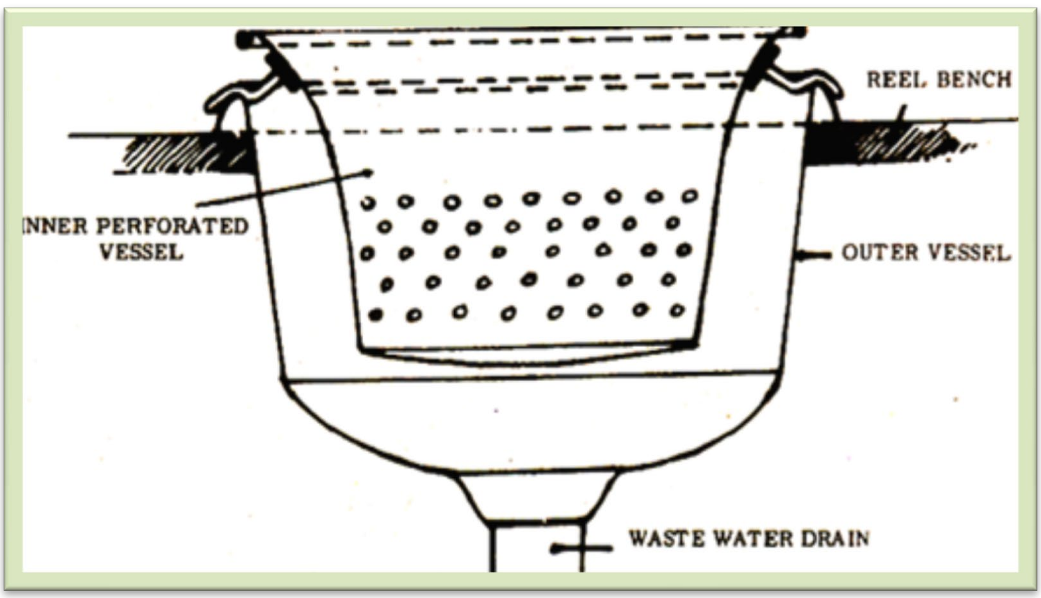


Fig 5.1 Open Pan Filature Cooking Basin

B. Three Pan Type

It is arranged with three large size porcelain or stainless-steel basins fitted in a row on a platform or table. All the basins are provided with water and steam connections. The other equipment of cooking is long handled brass wire cage (for holding the cocoons), a wire mesh disc with wooden handle (for keeping the cocoons immersed) and long handled perforated ladles.

All these are kept in a open shelf in the table accessible to the cooking operator. The table is also provided with a platform for keeping the boiled cocoons.

The temperature of each basin is maintained at the following levels.

I	**basin**	90°C	to	95°C	60 Sec
II	**basin**	60°C	to	65°C	30-40 Sec
III	**basin**	90°C	to	95°C	120 Sec

The water temperature in the cocoon carrier basin is kept at 40°C to 45°C.

The wire cage with required quantity of cocoons is immersed in the I pan for around 60 seconds, II pan 30-40 seconds and in III pan for about 2 minutes. In the first pan air from the cocoon comes out due to hot temperature of the water. In the second pan air inside the cocoon contracts and hot water permeates in. As a result, the cocoon shell layers are loosened and the hot water entering through the shell softens and swells the sericin layer and finally fills (partly) the cocoon cavity. The cocoons from the second pan are transferred into third pan and made to immerse with the help of wire mesh disc. The hot water of third pan soaks the cocoons and fills up the cocoon cavity to a considerable extent and dissolves a small quantity of sericin. Then cocoons and transferred to the carrier basin with the help of ladle for brushing (Fig. 5.2).

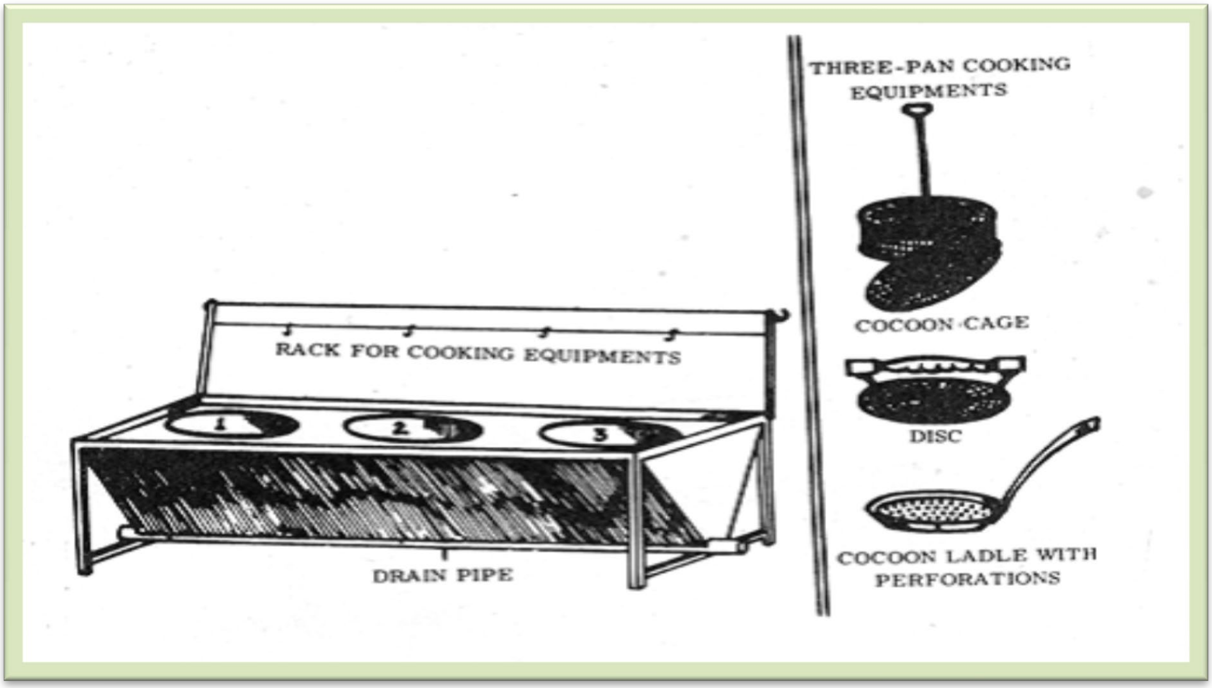


Fig 5.2 Three Pan cooking

In three pan cooking two methods of temperature are maintained i.e. high-low-high method and low-high-low method.

1: High-low-high method:

	I basin	II basin	III basin
Temperature	90-95°C	60-65°C	90-95°C
Time	60 Sec	30-40 sec.	120 sec.

After the third pan, the cocoons are received in a bucket of water at 45°C before they are taken for brushing.

2. Low-high-low method:

	I basin	II basin	III basin
Temperature	65°C	98°C	65°C
Time	60 Sec	90 sec.	60 sec.

The cooked cocoons are soaked in a bucket of water at 45°C for 10 minutes before being taken for brushing.

Advantages:

1. Each unit capacity is about 60-70 kg of cocoons per day. It can easily supply cocoons to 10- 12 multi end reeling basins.
2. Saves labour.
3. Permeation of water into the cocoon is systematic thus improves the unwinding quality of filament.
4. Uniformity in cooking is possible.
5. Since brushing is done separately the water does not become dirty.
6. Since cooking and reeling basins are different the reeler can concentrate only on reeling.

Disadvantages of Top Reeling:

1. Reeling has to be done at higher temperature which tends to affect the palm and fingers of the reeler and impair reeling efficiency.
2. Large quantity of steam is required for reeling water. Water vapour increases humidity and decreases visibility. It also adds to cost of reeling.
3. Increase the work load of the reeler as he is forced to carryon brushing or separate operator is required.
4. Separate cooking, brushing and reeling requires additional equipment and staff and space. However, the output compensates extra cost.

2. Sunken System:

The cocoons cooked by this method are filled with water about 90% and are sink in the water at the time of reeling. Cocoons in sunken condition in the reeling basin yield the silk bave more readily than in floating condition. This feature improves the reeling efficiency. The sinking condition is obtained by increasing the weight of the cocoon by expelling the air contained in the cocoon cavity and replacing it with water. In this process cocoon shell is cooked uniformly. Tepid or lukewarm water in reeling basin is sufficient during reeling process.

Conveyer Cooking Machine:

It is also called as central cocoon boiling machine and used in large scale modern reeling units. It consists of a sturdily built long, rectangular container firmly held in an iron frame. The container is internally subdivided into six processing chambers and open chamber for loading the cocoons. Each processing chamber has its own specification of size and constructional design to suit its particular function. Each chamber is also provided with independent water and steam circuits to facilitate maintenance of proper temperature and steam pressure, thermometer and pressure gauges, inspection windows. The chambers are provided with overflow and drain pipes for maintaining water level. Some cooking types are provided with thermostat and automatic control device.

Internally the system has an end-lees chain conveyor to carry a series of wire cages made of brass. The wire cages are meant to hold cocoons. With the mechanical operation the conveyor carries the cocoon through all the chambers. The cocoon cooking involves following continuous operations.

1. Pre-treatment (soaking, steaming, permeation), steam cooking.
2. Post-treatment (adjustment, post-permeation).

The pre-treatment aims at swelling the cocoon itself and the sericin in the cocoon shell by heating and replacing the air in the cocoon cavity with steam. The purpose of post treatment is to adjust the swelling of sericin and replace the steam in the cocoon cavity with hot water. All these process does not collapse the cocoon structure.

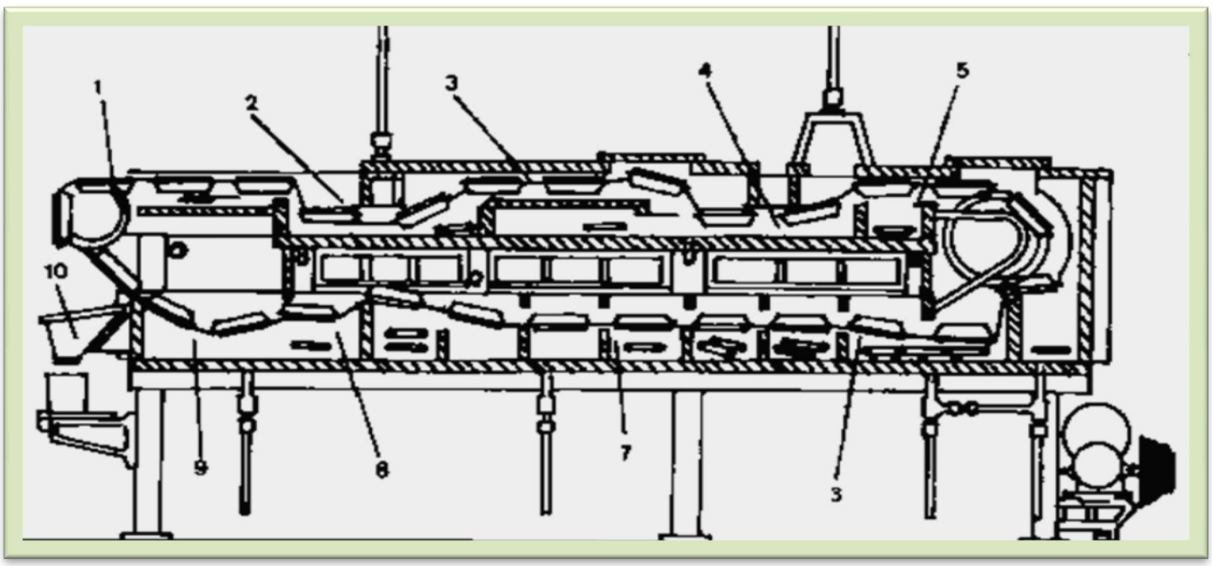


Fig 5.3 Central cocoon boiling machine

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

The six different processes of this system are as follows.

i. The first chamber is called soaking or wetting chamber. It has 40-42°C temperature and cocoons are treated for 30-50 seconds.

ii. Second chamber is steaming or steam blasting chamber functions at about 90-95°C at proper steam pressure. In this air inside the cocoon is heated to cause its expansion and partial replacement. Sericin layers become stiff and slightly less soluble. The duration in second chamber is limited to 60 seconds.

iii. The third chamber is permeating or infiltration chamber and has water at 40-60°C temperature. The water enters inside the cocoon during 30 seconds of treatment.

iv. Fourth chamber is steam cooking and has 95°C - 98°C temperature and 0.33 kg per cm2 pressure. This causes sericin to swell and soften the silk layers and steam to fill up the cocoon cavity during 118-120 seconds of treatment.

v. Fifth chamber is cocoon boiling where steam contents of cocoon are replaced by water by gradual cooling of water from 98C to 60°C. The length of treatment depends on the qualities of the shell.

vi. In sixth chamber water easily enters and fills the left-over space inside the cocoon at 50°C-60°C. The cocoons after 10-11 minutes are discharged in to a trolley carrying tub containing hot water (40 to 50°C) for transfer to brushing and reeling.

Advantages:

1. Cooking is uniform for all cocoons and in all layers.
2. Economy in fuel consumption
3. Silk Waste percentage is reduced.
4. Cohesion of reeled silk is good as over softening or dissolution of sericin is avoided.
5. It reduces mill dampness, vapour formation thus defects like hard gum spots, ribbing and plastering are prevented which improve ventilation and visibility.
6. Low temperature of water does not injure the fingers.
7. Reelability is improved and increase output.

5.3 Brushing and methods of brushing

The cocoons have to be brushed to remove the surface floss before reeling. Without removing the floss layer one cannot reel the proper silk. This waste layer obstructs the reeling process unless it is clearly removed. The process of removing floss layer is called “brushing”. In open pan cooking brushing is combined with cooking. But in three pan and sunken system it is done separately. After removing the floss layer, the ends of the cocoon thread are picked up so that reeler can feed them for easy reeling.

There are three methods of brushing;

1. Stick brushing 2. Hand Brush. 3. Mechanical Brush. 4. Central cocoon brushing machine

1.Stick brushing:

A thin, single, flexible, soft stick is used as brush (Fig.5.3.1). The reeler holds the stick at one end and constantly stirs the other end on surface of boiled cocoons in the cooking vessel / reeling basin itself in the form of figure eight. Stirring is continued till the stick collects the floss. When sufficient quantity of floss is taken off from the cocoons the stick is lifted from the cocoons about 25-30 cm up above the cocoons and lump is cleared by fingers to release the reelablebaves. Cocoons with reelablebaves are transferred to the reeling basin. The waste lump is further cleaned and dried. The stick brush is used in the charka system and other older types of reeling systems.

2. Hand Brush:

It is made with flexible thick and long fibres tied like a broom. It is generally made from Khus-Khus grass or any stiff straw. The brush is of 15-20cm long with a flat, circular brushing surface about 6-8 cm in diameter (Fig.5.3.2). The brushing process is more efficient and effective because of more number of bristles which gathers large quantity of floss. There is no risk of injury to cocoon structure.

3. Mechanical Brushing:

It is most suitable for filature reeling machines. After ladling the cocoons into the cooking vessel for a few minutes, the mechanical brush is lowered into the basin. The brush makes clock-wise and anti-clock-wise rotary movements (Fig. 5.3.3). After a definite number of movements (20-24) the brush is lifted out of the basin either by cooking operative or automatically. It is important to maintain the required temperature of water. After brushing of cocoons the operative carefully collects the outer floss layer and filaments are separated. The process is carried continued with brushing and called as “clearing the bave”. Generally, it is done by the cooking operative. But at sometimes it is carried in specially designed oval basin in a wooden tub / perforate dipper / ladle with the bave ends of the cocoons twisted and tied to the hook.

Precautions in mechanical brushing:

1. Well sorted, uniform size and build cocoons are necessary.
2. Only one layer of the cocoons should be on the surface of water. Water level must be constant in such a way that cocoons should touch the brush for effective brushing.
3. When the brush is lowered into the basin steam supply is stopped to avoid over-cooking.
4. Brush must be clean and free from clogging.
5. Unyielding cocoons returning from the reeling basin should be treated separately.
6. The reeling basin is suitably designed for brushing and reeling. This brush is similar to automatic brush but is has a number of small brushes projecting from the main brush holder.

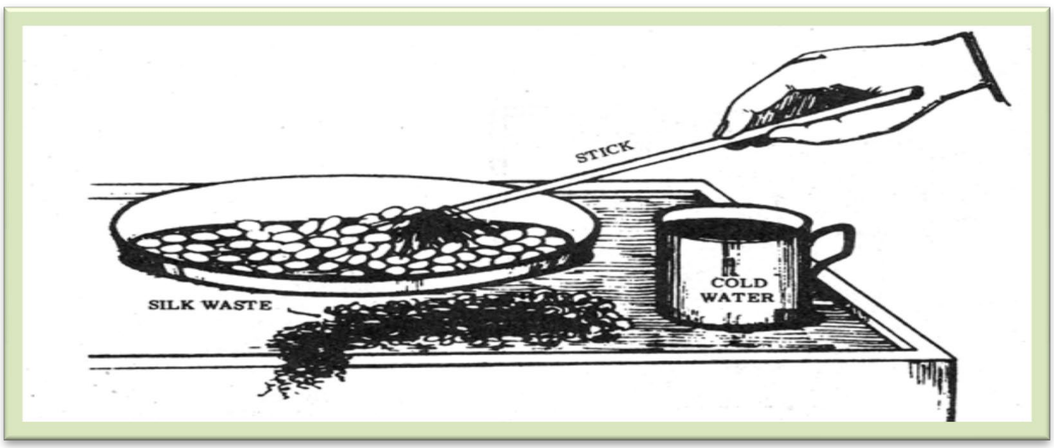


Fig. 5.3.1 Stick brushing

Fig. 5.3.2 Hand brushing

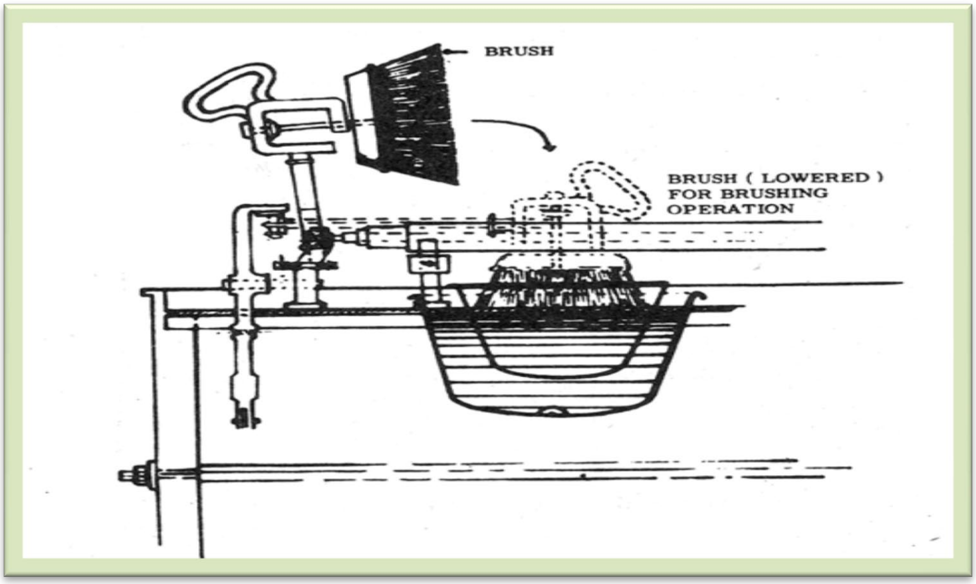


Fig.5.3.3 Mechanical Brushing

4. Central Cocoon Brushing Machine:

It is specially designed and automatic brushing machine which carries mass brushing of the cocoons. It is so designed for standardized brushing process and reduces the percentage of waste. It saves labour because of mechanical and automatic brushing (Fig. 5.3.4).

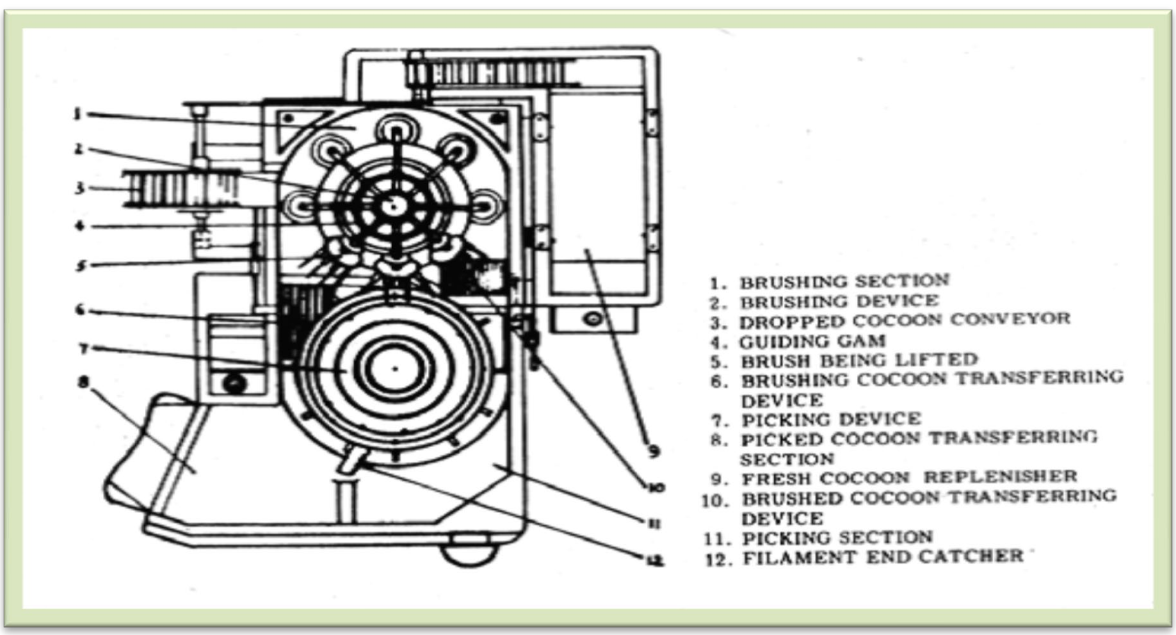


Fig 5.3.4 Central cocoon Brushing Machine

5.4 Summary

- Cooking is necessary for softening of the silk shell so as to reel the silk easily.
- In top reeling cocoons float while cocoons sink in the water in sunken system.
- In conveyor type cooking finally cocoons are filled with 90% water and cocoons are made useful for sunken system of reeling,
- Brushing process is must to gather filament ends required to start reeling process.
- Each method of cooking and brushing is suitable to different reeling machines.

I. Short Answer Type Questions.

1. Define cocoon.
2. Define raw silk
3. Define reeling
4. Define cooking or boiling
5. Differentiate bave.
6. Mention cocoon cooking methods.
7. Write the difference between top reeling and sunken system.
8. Mention methods of top reeling.
9. Define brushing
10. What are the equipment used for brushing?
11. What are the advantages of hand brush?
12. What are the advantages of central cocoon brushing machine?
13. How many layers are there in sericin?
14. Name the silk proteins.

I. Essay Answer Type Questions:

1. Describe open pan system of boiling.
2. Explain the process of three pan cooking.
3. Write about the advantages and disadvantages of top reeling.
4. Write about conveyor cooking machine.
5. Write short notes on the following.
   a. Circular type pressurized cooking b. Central cocoon brushing machine
7. Write short notes on the following.
   a. Stick brushing b. Suitable cooking and brushing systems for different reeling machines

Ψ

UNIT 6

Reeling

Structure

6.1 Introduction

6.2 Reeling apparatus and machines

6.3 Reeling water

6.4 Re- reeling

6.5 Silk Examination

6.6 Lacing and Skeining,

6.7 Book making and baling

6.8 Spun silk making

6.9 Non- mulberry cocoon reeling

6.10 Summary

Learning Objectives

After studying this chapter student will be able to…

- Know how to handle Reeling Apparatus and operations
- Know types of Reeling Machines and acquire knowledge in Re- reeling
- Examine the raw Silk
- Conduct Lacing and Skeining of silk hank
- Handle Book making and bailing of silk hanks
- Know how to conduct non- mulberry cocoon reeling

6.1 Introduction

Reeling is the last phase of sericulture which is involved with more technical industrial skills. The reeling process involves various stages or processes which finally judges the quality of silk. In general silk reeling is defined as unwinding of silk filaments from cocoons. However, it is technically defined as 'the process of finding the right end of the cocoon filament and jointly taking several ends together to reel raw silk'. These processes are carried using reeling machines which are operated by skilled person who is technically known as reeler. Reeling industry in India mainly depend on Charkha, Cottage basin and Multi end reeling machines. More than 75% of raw silk produced is only on Charkha. 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 and automatic reeling machines. In advanced countries like china and Japan automatic machines are very much in use because of their superior quality cocoon production.

The reeling process is carried out in two ways.

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

The production of Mulberry raw silk is mainly confined to the state of Karnataka, Andhra Pradesh, Tamilnadu, West Bengal and Jammu & Kashmir. Besides these Maharashtra, Kerala, Gujarat, Uttar Pradesh, Rajasthan, Bihar and Orissa also contribute in Mulberry raw silk production. In non-mulberry sector Bihar, Orissa, Madhya Pradesh, Andhra Pradesh and West Bengal are major contributors in Tasar raw silk production besides a small-scale production is found in Maharashtra and Uttar Pradesh. Major states of Eri raw silk producers are Assam, Bihar, Meghalaya, and Manipur while a small-scale production is seen in Arunachal Pradesh, Mizoram, Nagaland and Orissa. Muga silk is confined to Assam besides a small-scale production in Mizoram, Meghalaya and Nagaland.

At present reeling industry is of the view to capture the export market. Keeping in view of the importance of reeling industry a detailed study and information is given on different operations and apparatus / equipment for carrying reeling process in a systematic way.

6.2.Reeling apparatus and machines

6.2.1. Formation of silk thread

The required number of filaments or baves from brushed cocoon is taken to form required standard sized (Denier) raw silk thread. The baves are combined and passed through the guide-eye of a threader (button or jettebout). The baves coming out of button is passed over two or three small wheels or pulleys during which the filaments are twisted properly. The mechanism of twisting or intertwinement is technically called as croissure. This process is repeated at each guide to combine the filaments firmly. During this process maximum amount of water is squeezed out. A group of cocoons from which the standard thread is formed at each end is called rosette. Each place in the reeling basin where a thread is formed is called an end. At this point the filaments from the cocoons (rosette) forms a shape of cone which is called as balloon. (Fig. 6.1).

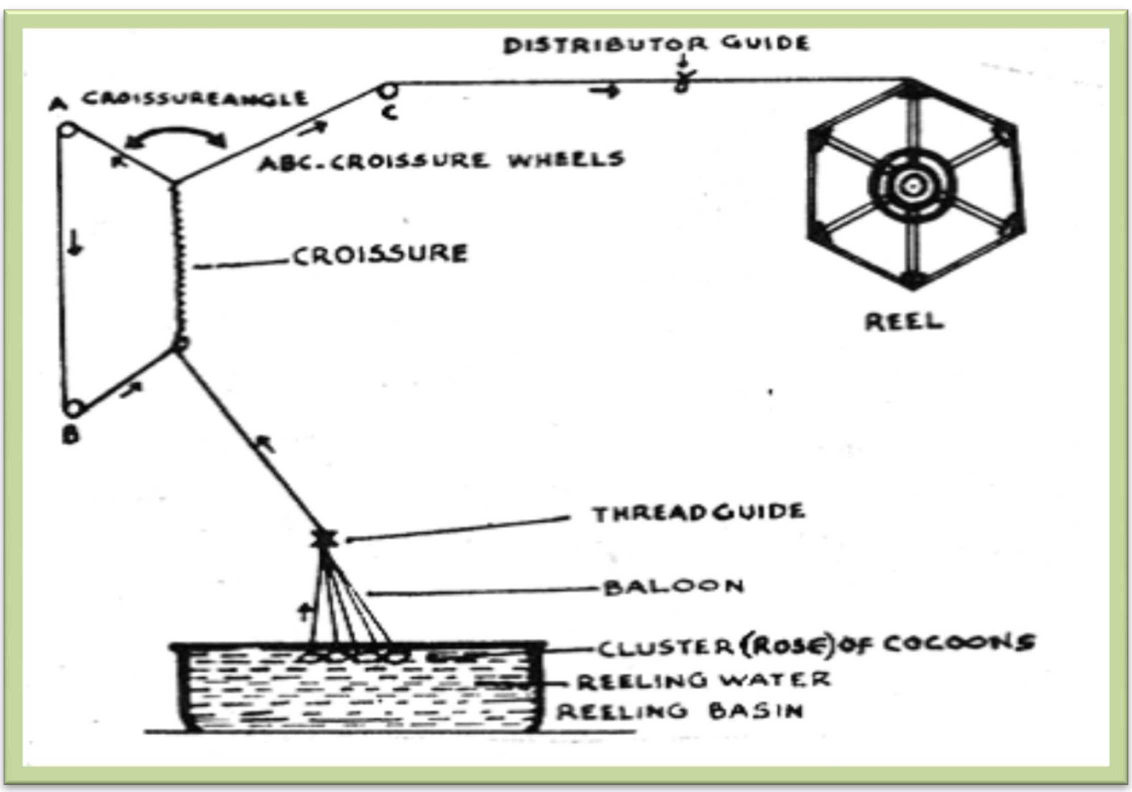


Fig.6.1. Raw Silk thread formation

6.2.2. Jettebout

In order to maintain uniform size and continuity of silk thread the reeler has to attach fresh filaments. The jettebout used for thread catching during reeling process. Each and every end of reeling basin is provided with one jettebout and all are rotated by continuous belt connected to reeling machine motor pulley. It consists of two brass tubes, the inner tube is with narrow bore which is firmly fixed to the jettebout frame, whereas the outer tube revolves on the axis of the cylinder and the thread comes out through inner tube hole. The outer tube has a circular disc with short slanting revolving arms with which bave is pulled and cut due its speed revolution. The cut end remains in the hand of the reeler while the other part of the bave falls on the fastmoving balloon and added to upgoing filaments to form thread. Number of filaments to be maintained to form required denier thread is made easy with the action of jettebout.

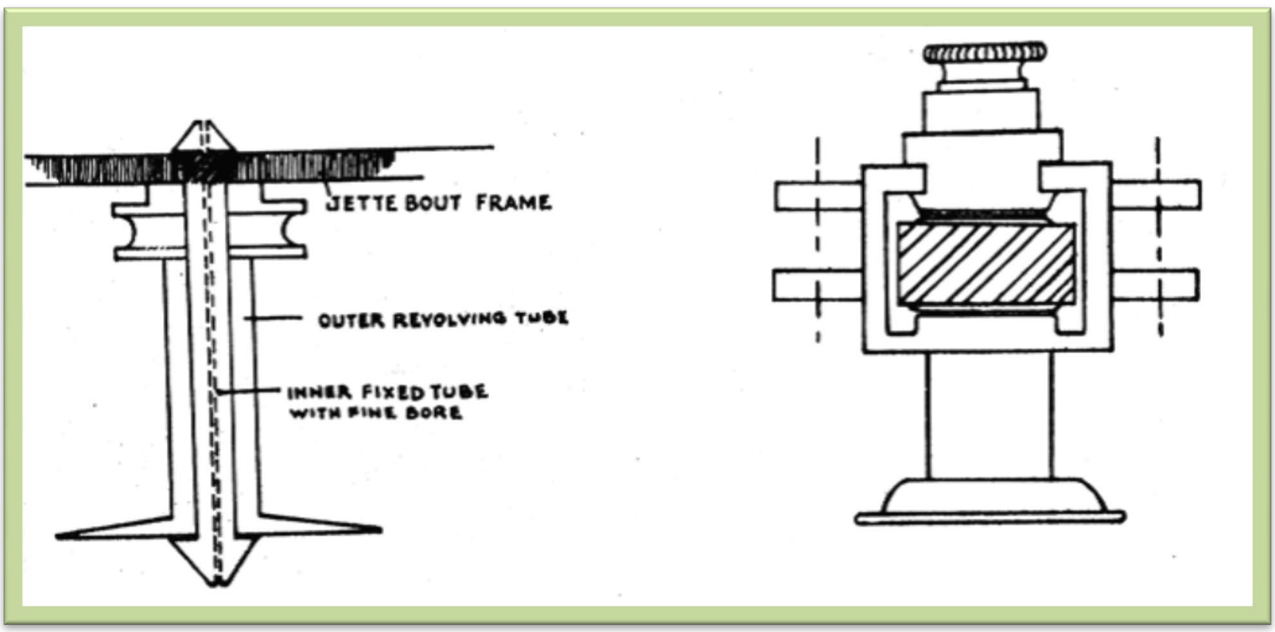


Fig.6.2. Jettebout A. Simple for rope drive B. Improved with gears

6.2.3. Croissure

The intertwining or crossing of two threads is made by twisting the threads in a series of spirals during its passage from the threader to the reel. This mechanism is called as croissure. This process makes the silk thread round, smooth and compactly cemented with an even coating of sericin. Otherwise the baves break in manufacturing of fabric and crease up to form fur on the yarn or fabric. Croissure also squeezes most of the water contained in the filament. If the sericin is wet, the threads wound on the reel will stick to each other and defects like hand gum spots result.

There are two types of croissures used in India.

1. Chamboncroissure

2. Tavellettacroissure

Chamboncroissure: In this threads from two reeling ends are intertwined to farm a few spirals. These two ends are taken through distributor and wound at two ends on the reel. The thread from the right reeling end is wound on the left side and that from the left side wounds on the right side of the reel. Its only advantage is that it does not require any elaborate arrangement on the reeling machine.

The disadvantages using chambon type are…

1. There must be at least two reeling ends for the threads to be twisted.
2. Formation of double threads is common.
3. There must be two separate ends of the reel.
4. Chambon type is simple and primitive, used in charkha reeling.

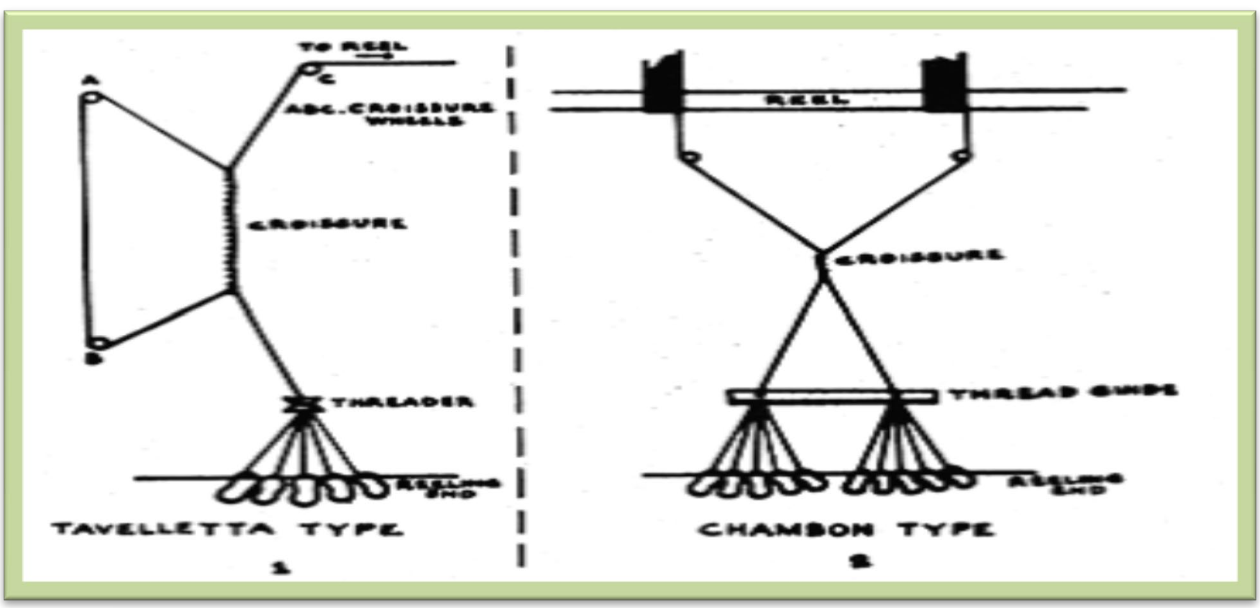


Fig. 6. 3 Types of croissure

Tavellettacroissure: This is universally accepted in all modern reeling machines. All the defects of chambon type are rectified and only single thread is used to form this croissure instead of two threads used in chamboncroissure. It has three pulleys (croissure wheels) fixed on the croissure frame. The single thread coming from thread guide passes over these three pulleys, before going on to the distributor and the reel. The length of the croissure or the twisted section is adjusted according to the size of the silk reeled and the speed of reeling. While reeling fine thread of low denier, the twisted portion is small and the reeling speed should be low. For high denier silk the twisted portion is large and reeler can increase the speed of reeling. The coarse size thread can easily withstand a higher reeling tension.

6.2.4. Reels

The important functions of the reel are

a. To pull the filaments from the cluster of cocoons and to help in forming a continuous thread.

b. To wind up itself the thread of raw silk produced.

c. Two sizes of reels are in use. One is small size reel of 60-75 cm and standard size reel of 145-150 cm circumference.

The silk thread from the croissure is wound on the reel. The reel size is not constant for all kinds of reeling machines. Its perimeter in direct reeling machine is 145-150 cm. In modern multi-end reeling machine, the reel perimeter is 60-75 cm. and smaller than in direct reeling machine. The standard reel (direct reeling filature machine) has six ribs made of wood and spaced at angles of 60°. While each rib is held on a pair of round iron spokes radiating from the main reel axle (Fig. 7.4).

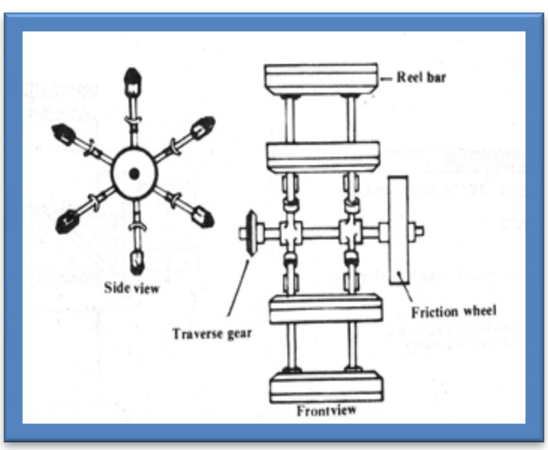
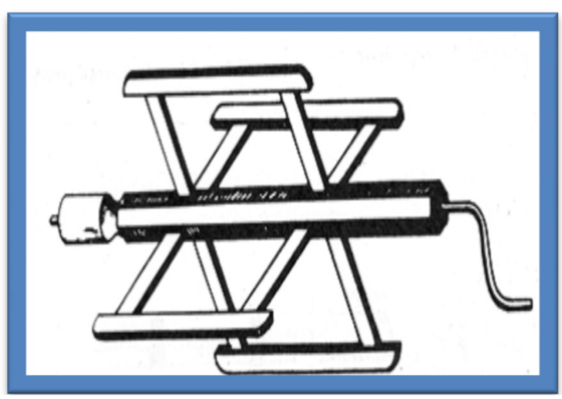


Fig.6.4. Standard reel.



6.5. Primitive reel

The reeled silk on small reels cannot be removed as hanks and has to be transferred to the standard reels by re-reeling or rewinding. The primitive reel is large in size and does not confirm to any standard pattern (Fig. 6.5). The production of reeled silk depends on the perimeter of the reel and its velocity. Further high speed increases the tension on the thread and leads to frequent breaks. This process increases wastage and reduces thread production. While low speed also reduces the rate of production besides impairs the qualities of cohesion and luster of the reeled silk. It also reduces the effective functioning of corissure. Generally, a thread speed of 120-150m. per minute is maintained in filature machine.

6.2.5. Traverse or Distributor

The silk thread leaving the croissure surely contains considerable amount of water. This water makes the sericin wet and sticky. This kind of silk when wound on the reel defects of ribboning and plastering occurs. All these cumulative defects in the hank spoil the winding quality leads to silk wastage. Various attempts were made to avoid these defects. Among them using electrically heated long shaft increases the length of the silk path between the croissure and the reel. This process ultimately withdrawn because of quick drying on hot surfaces spoils the strength and luster of the silk. Keeping in view of these defects the standard reel was modified. The reel with rounded reel bars was found to give satisfactory results. These reels are used in rewinding machines.

6.2.6. Grant reeling

Each reel operates its own traverse mechanism consisting of a set of gears with specific ratios between them. This makes to obtain the particular pattern and number of webs or diamonds across the face of the hank. This hank should be of international standard hank. This is known as grant reeling. If there is no such mechanism it causes much delay in the knotting operation when a thread break. This grant reeling technique is adopted in direct reeling as in the re-reeling mechanism (Fig.6.6).

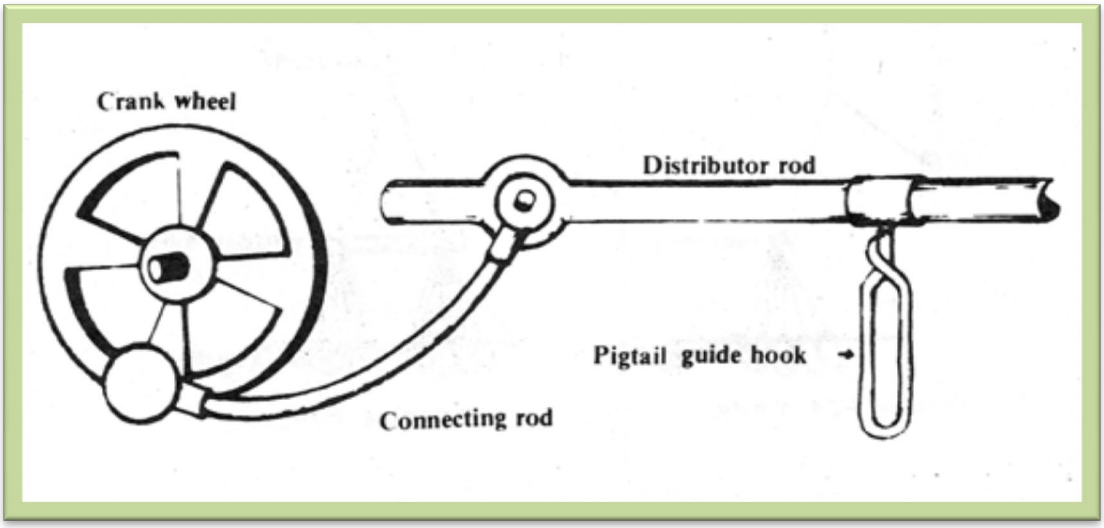


Fig.6.6. Grant Reeling hormonic traverse

6.2.7 Reeling machines

Silk reeling is the process of finding the right end of the cocoon filament and jointly taking several ends together to reel raw silk. In other words, unwinding of the silk filament from the cocoon with the help of a reeling machine is called silk reeling. Cocoons are generally reeled in two ways.

(i) Direct reeling on standard reels

(ii) Indirect reeling which includes preliminary reeling on small sized reels and transferring the reeled silk from the reels to standard sized reels on re-reeling machines.

Majority of silk reeling in India is done on low cost reeling methods like country charkha is due to inferior quality cocoon production. But in recent years after evolution of new races of cocoons and advanced reeling machines quality silk production is made possible.

Methods of Reeling

The several methods of silk reeling are

1. Reeling on traditional charkha
2. Reeling on cottage basins/domestic basins
3. Reeling on multi-end reeling basins
4. Reeling on semi-automatic reeling machines
5. Reeling on automatic reeling machines

6.2.7.1. Traditional Charkha (Country Charkha)

The country charka is a manually operated reeling system extensively used in the cottage reeling sector of the Indian reeling industry. It is entirely traditional and home-built by locally available wood with the help of the village carpenter and blacksmith. The charkas are generally installed in the backyard of the houses or in the simple roofed shelter. Each charka consists of three parts.

1. Mud platform
2. Distributor
3. Charaka reel

The mud platform is in a rectangular shape measuring about 60 x120 cm with height 90 cm. It has a built-in fire place with a basin fitted over it, which is either a mud pot or a copper vessel, generally oval in shape with a diameter of 45-50 cm. The basin is buried up to its brim in the mud plat-form and there is a place for the reeler to sit on the platform. Below this basin fire place is provided to boil water which is used for both cooking, brushing and reeling operations. The other parts like thread guide (Tharapatti), distributor and reels are arranged above this plat form. The thread guide (commonly called tharapatti) which is made up of a metallic strip with two apertures on it. It is securely fixed at the end of a thin long stick leaning against the front edge of the mud platform and rests just above the basin. A chimney is provided on fire place for the smoke to escape. A simple device popularly known as distributor consists of a wheel which revolves on its vertical axis and drives the wooden traverse rod backward and forward. The traverse rod is parallel to the front side of the platform and stands about 20-25 cm above. The traverse rod is provided with small wire loops along its length at regular intervals to serve as a thread guide for the threads passing through them on their way to the reel. When reeling is in progress, the traverse rod moves briskly to and fro in front of the reel and distributes the silk evenly in cross winding to form diamond cut shaped ribs of silk thread on reel.

Each reel can accommodate about four ends. The reeler takes a handful of cocoons and keeps the water in the basin at boiling point, and cooks them and remove floss by brushing with the help of a stick he collects the ends of all the cocoons. He holds them in a bunch in one hand and takes the required number of filaments from the cocoons for passing through the two apertures of tharapatti and two threads intertwined in the form of a croissureare separated to wind on to the reel through the distributor guide. The reel is rotated manually by a separate turner and reeling is continued.

Advantages:

i. Low cost of construction.
ii. Even the inferior cocoons are reeled.
iii. In this system, the cocoon is reeled up to the last layer of silk in the cocoon by maintaining the high temperature in the reeling basin and, hence, the yield of silk from a cocoon unit is more while the renditta will be less.
iv. The silk yarn produced in this system contains more slugs and is not clear. It is generally used as weft in certain types of fabrics.

Disadvantages:

It is not possible to produce high grade or fine quality of silk as the denier will not be uniform. This is because the number of cocoons in reeling cannot be maintained uniformly throughout the reeling.

i. The water in thebasins becomes dirty and coloured due to continuous boiling and reeling. Hence the raw silk obtained will be dull in colour.
ii. Knotting is not possible whenever there are breaks, so there will be a number of loose ends in thesilk reeled. This willresult in more winding breaks and winding waste.
iii. The reeler has to change the water in the basin 4 to 5 times in a day increases water usage.

Fig-6.2.7.1 Country charkha

Improved Charkha:

The widely used country charkha in India has been undergone so many changes to improve the quality of raw silk produced on it. CSR&TI, Mysore conducted wide research on this and finally evolved an Improved Charkha without increasing its construction cost much. The Improved Charkha provided with so many additional provisions like separate reeling and cooking basins, arrangement of electric motor for rotating charkha and more number of reeling ends. With these improvements the quality of silk also widely improved.

6.2.7.2 Cottage basin:

This is another system, which is used widely in the reeling industry after country charkha. It consists of a separate cooking unit comprising three or four cooking basins fixed in a row. The cooking is separately done without disturbing the reeler. The reeling unit consists of 4-6 reeling basins fixed on a table with the dimension of 45 x 257.5 cm. Hot water for the reeling basin is supplied through a tap drawn from the water heating drum fitted in the cooking unit.

The croissure frame and the drive wheels on the transmission shaft are made of either wood or iron. Each basin is designed to reel 4-6 ends. To facilitate the easy catching of filaments jettebouts are provided for each end. Each basin has its independent modern tavellettacroissure. The reel frame consists of an angle iron or wooden frame fitted above one meterhight and parallel to the reel bench.

The height of the reel bench is generally about 150-170 cm from the ground, to enable the knotter to move freely in the passage to attend the knotting of thread. The reels are driven by drive wheels fitted on a common transmission shaft. The traverse mechanism at the end of the transmission shaft consists of the required gears and cam for imparting to and fro movement to the traverse bar, and at the other end of the transmission shaft a handle is fitted for rotating the reels.This is a slightly improved design over the domestic basin which is in line with multi-end basins. The cottage basin has overhead small reels with separate equipment for re-reeling.

Fig.6.2.7.2 Cottage Basin Reeling Machine

6.2.7.3 Multi-end Reeling Machine

The multi-end reeling machine has a slow speed reeling and thread production on small reels with multi-ends. The slow speed reeling minimizes the thread breaks and produces quality silk thread. Re-reeling is easier and produces little waste and produces silk of improved quality. The reeler is not strained in the performance of the reeling operation.

The multi-end unit is provided with three-pan cooking systems. The reeling unit consists of two parallel row of reeling basins with a set of overhead small reels. The reel bench is of convenient height to enable the worker to sit on a stool and conduct reeling.The reeling basin is rectangular and 10-12 cm. deep with the outer edges well rounded made of stainless steel. Each basin is provided with overflow drain, many jettebouts as there are reeling end and also tavellettecroissure for each end.

The reels of the multi-end machine are of a small size with a circumference of 60 to 75 cm. Reels are made with hard plastic and designed to wind up itself only one hank. Each basin has as many reels as there are reeling ends. The reels are slipped over a common carrier shaft driven by connecting gears from the main shaft. The shaft is provided with a mechanical brake to stop the whole series of reels and each reel can also be stopped by a stop motion device provided for each reel which works automatically on the appearance of larges slugs and waste in the raw silk thread. All reeling machines are provided with porcelain button thread guides with a tiny aperture for the thread to pass though. The machine is provided with speed regulators. The machine is made free from vibration to ensure better durability. The multi-end machine ensures increased raw silk quality productivity. Superior quality of reeled silk and reduces waste. The silk reeled on this has to be re-reeled on to standard reels of the re-reeling machines

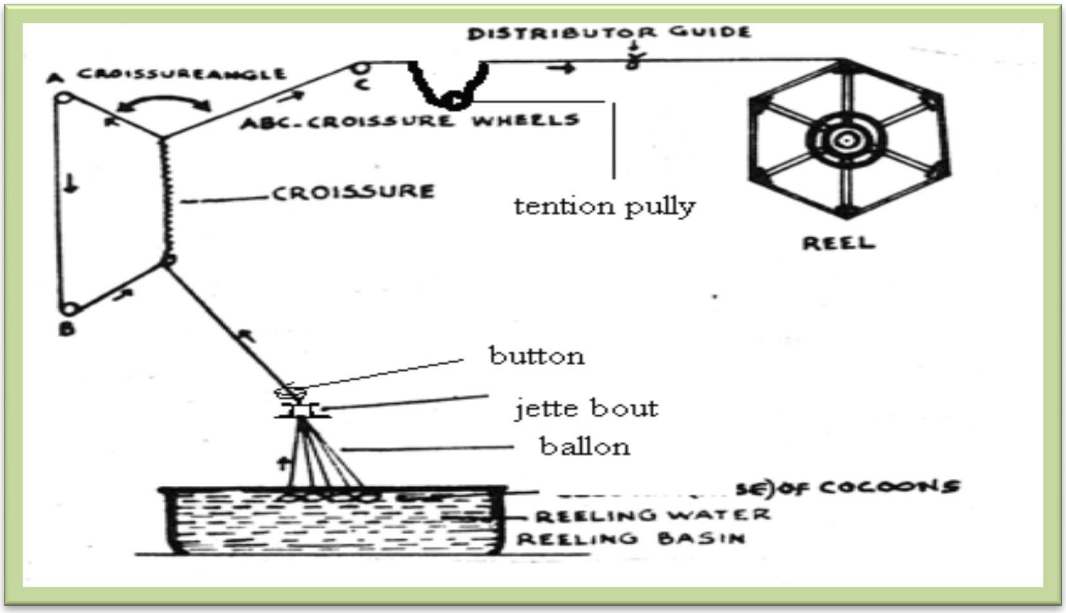


Fig.6.2.7.3.a Thread formation in Multi-end reeling machine

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Fig.6.2.7.3. b Multi-end Reeling Machine

6.2.7.4 Semi-automatic reeling machine

This is a mixed-mode or hybrid machine between the automatic and multi-end reeling machines. As an application, this type is better for improved reeling efficiency and raw silk quality than the multi-end reeling machine. The semi-automatic reeling machine can be operated with poor quality cocoons also, but relies on more labour than the automatic reeling machine. Mechanism is exactly like automatic reeling except cocoon feeding is done manually.

6.2.7.5 Automatic reeling machine

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

Generally automatic machines are of two types based on denier or size of silk thread.

1. Fixed size type, fixed size thread is reeled by using fixed denier button guides.
2. Fixed number type, where fixed number of cocoons are taken to reel fixed size (Denier) thread

In Automatic reeling machine processes of groping ends, picking ends; cocoon feeding to reeling thread and separation of dropped end cocoons are done by machine automatically during the reeling process. The Automatic reeling machine though built to replace manual reeling, still requires manpower for problems with the reeling thread, which must be corrected by hand. Generally, one set of the Automatic reeling machines has 400 ends, while one basin has 20 ends. The operating efficiency of the Automatic reeling machine is easily affected by cocoon quality, drying and cooking machinery and quality of reeling water.

A moderate amount of cooked cocoons are carried to the newly cooked cocoon feeder and then removed into the groping end part. The end groped cocoons go to the picking end part and the correctly picked end cocoons are dispensed to the cocoon supplying basket which continuously rotates around the reeling basin on an endless chain belt. The reeling method is also classified into the fixed cocoon feeding system and moving cocoon-feeding system. The reeling thread fed by picked end cocoons passes through the jettebout, silk button, first guider, second guider, third guider, fourth guider, denier indicator, fifth guider and traverser, and then it is finally wound onto small reels. The end dropped cocoons are placed into the cocoon flowing tunnel by the remover plate. They are carried into the pupa separating drum.

In the case of the moving cocoon feeding systems, the correctly picked end cocoons are contained in the moving cocoon basket equipped with cocoon feeding apparatus. They are fed by the feeding fork of the cocoon basket, which move simultaneously around the reeling basin. The denier indicator of the reeling thread indicates the feeding motion of the cocoon. After cocoon feeding, the reeling path of the moving cocoon feeding system is the same as that of the fixed cocoon feeding system.

1. Brushing and picking section

An automatic ten-brush unit brushes cocoons with independent arms rotating in reverse motion on an axis in circular basins. Picking frames rotating in one direction pick off the brushed cocoon filaments when a cam during the operation raises the brushes. Selective picking is completed in the most effective manner by this equipment. To maintain the exact number (fixed number type) of cocoons at each reeling end, a control device is attached which detects the number of cocoons in the cocoon suppliers and automatically supplements required number of cocoons.

2. Reeling section

The Denier indicating and detecting device: In these devices, the yarn constantly passes through the denier indicator and detector, which are set to a given fixed size. The size of thread being reeled is detected through the balance between the friction of the running thread and an eccentric weight fitted on the denier indicator. When the thread becomes thinner than the fixed limit, the denier indicator (fixed size) indicates the necessity of feeding-ends. The size of yarn may be adjusted to the required sizes by varying the irregular weight with the denier-adjusting device; if a wider range of adjustment is required the denier indicators have to be replaced.

Conveyor system for cocoon suppliers: The fixed end feeding system is employed together with a conveyor system to carry cocoon supplies and feed cocoons to the reeling section whenever required.

End feeding for cocoons suppliers: Cocoons are supplied to the conveyor, which rotates constantly around the reeling section. The feeding lever fixed to the detecting mechanism will trigger the driving lever on the cocoon supplier only when the size of yarn becomes thinner than the required denier during reeling operation.

Stop motion mechanism: If there is a defect in the reeling or a break in the thread, the reel is automatically stopped by a brake, which is activated by contact pressure from operation of the detector level.

Dropped cocoon gatherers: The apparatus gathers baskets that have collected all cocoons dropped during end feeding. These are carried to the dropped cocoon separator. These baskets travel intermittently between the cocoon suppliers.

Separator of dropped cocoons: The device accurately distinguishes and separates pupae, dropped middle layer cocoons and thick layer dropped cocoons.

Fig. 6.3.1.5 Automatic reeling machine

6.3 Reeling water:

6.3.1 Importance:

In a silk reeling establishment, a large amount of water is used for cocoon cooking, silk reeling and re-reeling, in an addition to its use in the boiler. About 15,000 gallons of water are used to manufacture about 1000kgs.silk yarn. It is essential to select the quality of reeling water carefully as it has grave effects on the reeling efficiency, raw silk quality and during drying process..

The water used for silk reeling should be free from following.

i. Impurities and coloured organic matter in suspension may also spoil the colour and luster of the silk.

ii. The hardness of water affects essentially the surface characteristics of the raw silk-colour, luster softness etc. is due to the fixative effect of the sericin fibre on the salts.

iii. The qualitystandards for the water used in the reeling industry are asfollows.

- Water should be colourless, limpid and odourless.
- pH of the water should be 7.0 at ambient temperature
- Total hardness should be less than 75 ppm.
- Total alkalinity should be less than 50 ppm.

iv. Ph of water can be estimated by following methods.

1. Colorimetric Method
2. Electrometric Method

1. Colorimetric Method for pH of Water

- Take the pH standard solution and the water that is to be tested. Take the colorimetric paper. Dip this paper on the water sample. The obtained color is computed from the standard table and the respective pH value is recorded. This pH Value will conclude whether the sample of water is acidic or alkaline.
- **Electrometric Method for pH of water**

One of the most widely accepted method for the hydrogen ion determination (pH) is the electrometric method. This method is highly accurate and used in laboratory work and by researchers. The accuracy of the pH value is 0.1 to 0.0001, for which pH meter is used. For procedure and method refer ***practical manual*** (Paper III).

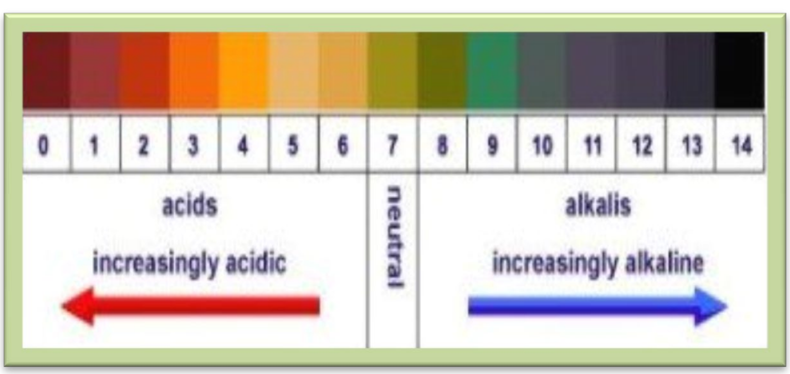

Fig.1. Standard pH Chart

6.3.2 Corrective Methods:

Elimination of suspended matter in water is done by sedimentation and filtration. Water is allowed to pass through layers of sand, charcoal and gravel. This removes suspended impurities. Correction of hardness of water can be done by passing the water through the water softener. Correction of alkalinity can be done by adding citric acid, tartaric acid or lactic acid.

Impurities in water are discussed under the following headings…

a. Turbidity and colour
b. Alkalinity
c. Hardness
d. Iron and manganese

a. **Turbidity and colour:** Turbidity may be caused by large or small mineral and organic particles suspended in the water. Sedimentation in tanks or reservoirs is adequate to clear large particles, but filtration is needed for small or colloidal fragments. Filtration using sand or the use of coagulants followed by filtration may be indicated.
b. **Alkalinity:** Raw water contains bicarbonates in amounts dependent on their origin. Often, water may contain small amounts of carbonate alkaline. The number of bicarbonate and carbonate ions present may be isolated by titration using phenolphthalein as an indicator and methyl orange as an indicator in the second stage.
c. **Hardness of water:** Water hardness is caused by calcium and magnesium salts. Other contributing elements to hardness include metallic ions such as iron and strontium. Note that if metallic ions are present they will be found in minute quantities compared to salts. Hardness is described as permanent and temporary; where permanent is caused by nitrates, chlorides and sulphates, and bicarbonates, which may be boiled to precipitate into carbonates and removing the hardness, cause temporary.
d. **Iron and manganese:** Iron and manganese may be found in water depending on the source of the contamination. The three types of impurities are: a) Ferrous and manganese bicarbonates in well waters when high amounts of free CO_2 are present, (b) Ferrous and Manganese sulphates in rivers containing acid mine-waste waters, or (c) Iron and

Manganese mixed with organic waste. Iron is present in some waters at the source, but corrosion in pipelines and storage vessels may taint water. If a given source is alkaline, iron in the form of ferrous bicarbonate may be removed by aeration when ferric hydroxide is there.

e. Water quality can be got tested at CSTRI and its Sub-units by bringing 1 litre of water in a clean plastic can. CSTRI water softening chemical (Oxipon – WSC) can be used if necessary, on the basis of recommendation given by CSTRI. As per the recommendation of CSTRI, reeler can adopt any one of the softening methods i.e., use of water softening chemical (Oxipon-WSC) or use of water softening plant, to soften the water to make it suitable for reeling.

6.4 Re-reeling:

The re-reeling operation is simple and skilled job. The direct reeled silk hank gummed threads at the reel points are loosened and placed over the swift. Wetting agents can also be used to soften the gummed threads. The thread end from the outer surface of the hank is taken over the tension rod and through the guide hole of the traverse and attached to the reel. The reels begin to revolve when brake is released where the thread from the hank is pulled and unwound to wind on the reels of the re-reeling machine. During the process of re-reeling thread breaks occur at a weak spot as it cannot withstand the tension. Then the operative removes the length of thin thread from the hank on the swift before uniting the broken ends and restarting the rewinding operation. Re-reeling machine is used for rewinding the silk from small reels is almost similar to the machine explained earlier. This machine lacks swift rack and the silk is reeled off by placing the reels on the ground. The reels are wetted by water or mild wetting agents before re-reeling .In any case re-reeling is the process which facilities the packing, where direct reeled silk is wound on to a standard reel (1.5 mt. in circumference) to make skeins of a certain length, width and weight. The weight of the skein is generally kept at 70 gm. up to 33 D, and 140 gm above 34 denier raw silk.

Fig.7.15 Re-reeling machine

6.5 Silk examination:

The raw silk hank is visually examined before it is skeined. The silk examination is carried in rectangular hall running east to west and having sky lights of special ground windows on the northern side. It is done in good defused natural light. Artificial lighting is very rarely restored to. First raw silk hank is stretched on the silk examination stand. Then reel points or the ribbed places of the hank are opened carefully by rubbing till the silk filaments are loosened. This process is carried carefully. After opening of the ribbings, the easily removable direct dirt and other defects (i.e. loose threads) are carefully picked and removed. Then long knots are trimmed properly by scissors and broken knots are repaired properly. Further coarse and too fine lengths of thread are removed.

6.6 Lacing and skeining

Lacing:

In this process the two ends of the silk hank are tied with coloured thread. To keep the diamond pattern of the hank from disc leveling threads of different colour are laced in between to keep the hank in position. Lacing is a process in which a thread passing across the hank in such a way so as to divide it into five equal parts. So that the threads are kept in place to ensure that the thread can be unwound easily. Unlaced silk has threads in an entangled manner, which results in breaks and finally wastage of silk. Lacing is done with silk or cotton thread which can be snapped or broken easily by hand. Generally, coloured silk thread is used for securing the ends and white thread for the lacings. For differentiating different denier of silk also different coloured threads are used (Fig 6.6).

Skeining:

After cleaning and lacing the raw silk is skeined. It is done by twisting the hank several times and folding it upon itself in a number of spirals in such a manner that the silk threads in the hank do not get ruffled or entangled of the silk subsequent process of booking and bundling and general handling of the silk until it is opened for use in the twisting operation. The skeining process is carried by a separate set of operatives using skeining machine or a turner. In skein making one end of the laced hank is carefully passed over a short brass tube held in the palm of the operative. Then operative gives several turns to the handle by holding the silk hank tightly. Further the operative places his fingers at the center of the twisted hank and folds the hank upon itself. Because of the twisting given previously the hank when folded turns by itself in spirals.

Fig6.6. Silk Examination and Lacing

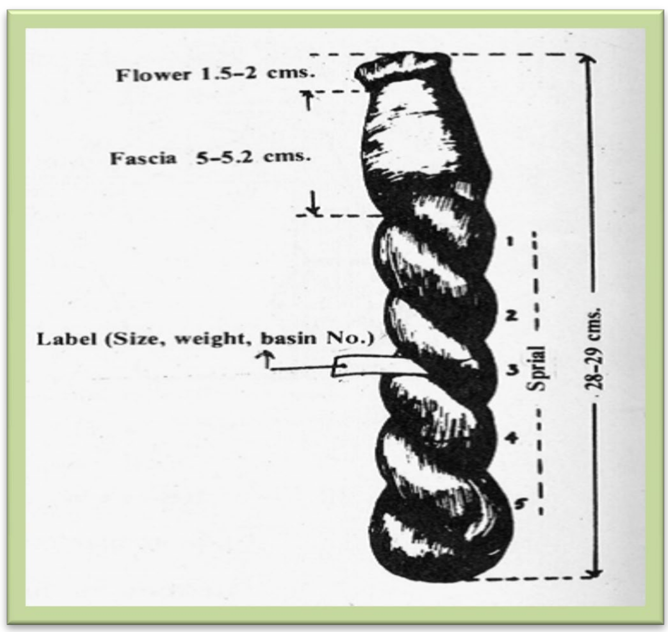

Fig. 6.6.1 Skein

After unhooking the hank from the skeining machine, slip through the loop of the other end of the hank held in the palm. Thus, the end emerging from the loop is opened out and extended into a circle which is known as the flower or fiacco crown. This structure protrudes about 1.5 to 2 cm above the loop. The silk thread of the loop is carefully spread out in a fascia about 5 cm wide. The standard loop has five distinct spirals, a loop and fiacco (Fig. 6.6.1). This skin is inserted with a slip of paper bearing the number of the basin.

6.7 Book and bale making:

All the skeins are packed into books and baled or bundled. The skeins are made into neat books of approximately equal weight and dimensions in a bookmaking press. Eight skeins in the horizontal row and five in the vertical row (Fig6.7) are kept in book making press neatly tied with separate cotton bands at three places and wrapped in tissue paper after considerable pressing. The books are further wrapped in thin cotton cloth first and later in Hessian cloth. The details about the number of skeins in a book, with their denier are marked on pack before sending for marketing.

Fig 6.7 Book making and baling

Storage of silk:

The bales of silk are stored in humidity-free, air-tight rooms to protect the silk from damage. The necessary fire-proof arrangements are provided. The store room should be well protected from insects.

6.8 Spun silk making

It is produced form different types of reeling wastes and some un-reelable cocoons. It is produced by hand spinning or machine spinning. It is used as spun silk yarn or indirectly as blended yarn by mixing with other natural or manmade fibres. The fine quality silk waste like filature wastes, cooker's waste, reeler's waste, re-reeling waste, throwster's waste are of high quality and used in spun silk mills for spinning fine yarn. While defective cocoon, boiled-off cocoons, palade waste are used in hand-spun yarn production pierced and cut cocoons are utilized for the production of hard spun-yarn known as matka yarn. Among the reeling waste 30-35 percent is used for spun silk and 20-25 percent for noil silk production. With an average 100 kg of silk waste, 16 kg of spun yarn and 12 kg of noil silk are produced in the spun silk mills. This silk can be used in fabric weaving and also used in packing pencils or puffs for talcum powder. Short lengths of inferior silk filaments taken from waste material are combed and spun together as silk thread. Spun silk threads are soft but less lustrous, strong and elastic than reeled silks. Spun silk fabric will become fuzzy with wear as the yarn is made from short material.

There are several sources to fabricate spun silk:

1. Pierced cocoons, the result of breeding moths that have emerged from their cocoons.
2. Double cocoons, which result when two cocoons have been spun too closely together.
3. Floss, brushed from cocoons before reeling.
4. Friese, the coarse and uneven silk fibre at the beginning and end of each cocoon.
5. Scrap, the machine waste left over from reeling.

The spun silk manufacturing processes are as follows:

1. Degumming the silk waste: It is done in degumming vats. (Degumming process is given in 8th Chapter dying)

2. Dryers for drying the degumming material.

3. Openers for opening the fibres.

4. Fillers for opening and cleaning the material.

5. Dressing machine is used for combing the materials nap's and remove the foreign materials, nap's and short fibre and make a lap with average staple length.

6. Spreader: To further make the fibers parallel. Set frames for obtaining sliver.

7. Draw frame is used for making the Sliver with fibres more perfectly paralised, blending also can be done by this machine.

8. Roving machine for making roving (standard of thread with little twist from silver).

9. Ring frame is used for making the spun yarn from roving and insert sufficient twist for strength and wind in a bobbin.

10. Winding & doubling machine are used for two or three fold commercial yarn.

11. Gassing is done for removing the protruding fibres by passing the yarn through the flame at a speed 500-600 mts/min.

12. Reeling to make standard sized hank.

13. Bundling & Balling: First make a bundle and bale for disposal of the material.

The size of spun silk thread is defined in a similar manner to standards used for cotton yarn. For cotton, the term "2/60s"signifies a two-ply yarn consisting of two single strands twisted together, each having a yearn count of 60. In the case of spun silk the notation has a different meaning. For example, for 60/2 two yearns with a separate yarn count of 120 have been doubled, producing a ply yarn with a new count of 60.

Fig.6.8 Flow sheet for spinning process

6.9 Reeling of non-mulberry Cocoons

a) Tasar cocoon reeling:

Tasar cocoons have a compact structure and composition distinct from that of mulberry cocoons. The cooking methods and chemical treatment shown in Table 1 reflect details of Tasar cocoon processing.

- The Sitting type dupion silk reeling machines are used for 110 and 225 denier Tasar silk, and Mult-ends reeling machines or Pedal reeling machines are used for the fine 42-63 denier silk.
- The "Natwa" pedal reeling machine used for fine Tasar reeling is made of bamboo and wood. While productivity is low, it is widely used in India because it is simple to operate and requires small investment cost.
- The machine has 4 spindles and a wooden wheel of 50-cm circumference for winding the yarn. It is driven by a foot pedal and the cocoons are reeled by hand. Preferred sizes of Tasar silk are 40/44 D and 60/66 D.
- Cocoons require a severe treatment for degumming. It is seriously affected by an alkaline solution of copper hydrate in glycerol. Soda ash and soap both followed by hydrogen peroxide partly bleach it and reduce the luster. Hydrogen peroxide and sodium silicate preserve the colour.
- The cocoons are stifled by boiling them in water for half an hour and drying under the sun rays. This effectively kills and dries the pupae and enables prolonged storage.
- The cocoons require to be softened and the filaments loosened before reeling. This is an elaborate process consisting of presoaking of cocoons in an alkaline bath and later steam-cooking for several hours.
- The outer layer with the peduncle is carefully peeled off and the inner cocoon shell is taken for reeling.
- Filaments from 5-6 cocoons are drawn and reeled into a twisted thread.

- The wet cocoons are placed on wet cloth and the filaments are passed through a thread guide and over a roller before the end is passed through the twisting mechanism and attached to the bobbin.
- When the machine is in operation, the roller draws the filaments from the several cocoons in the end, and feeds the grouped filaments to the twister before the twisted thread is wound on the bobbin.
- A simple distributer mechanism distributes the thread uniformly on the bobbin.
- The thread so formed is transferred to standard reels by re-reeling.
- Generally four ends are reeled by a reeler, and about 700 cocoons are utilized for producing about 250 gm of reeled yarn per day.

(b). Muga cocoon reeling:

- The golden cocoon or light brown in appearance, 4.5 to 6 cm long by 2.2 to 2.7 cm broad with a rudimentary peduncle.
- The outer surface of the cocoons is slightly flossy, and this can be easily removed by brushing.
- The cocoon contains 350 to 400 m length of reelable silk filament with a denier of 4.5. The filament has high tensile strength.
- Reeling cocoons are stifled by exposing them to hot air, followed by Sun drying. The cocoons are sorted into good and flimsy, before reeling.
- Pierced cocoons and the silk wastes from reeling are used for spinning.
- Reeling of Muga cocoons is simple, though cooking is elaborate.
- Cooking is done in boiling alkaline solution for about one hour for removing the natural gum which binds the filament in the cocoon.
- The cooked cocoons are reeled in tepid water heated over a slow fire.
- The true end of the filament is found and a number of filaments form as many as 7 to 20 cocoons are rolled together between the palms of the right hand across the thigh, while the left hand works the roller for winding the yarn.

A slightly improved method of Muga reeling consists in using equipment locally known as ‘Bhir’. This equipment consists essentially of a basin to serve as a water bath for the cocoons and roller with a large wheel at one end for wrapping. There is also a new machine which is provided with a bobbin and spinning mechanism for imparting the twists to the reeled yarn. The average production of raw silk is about 250 gm from 1000 gm of Muga cocoons

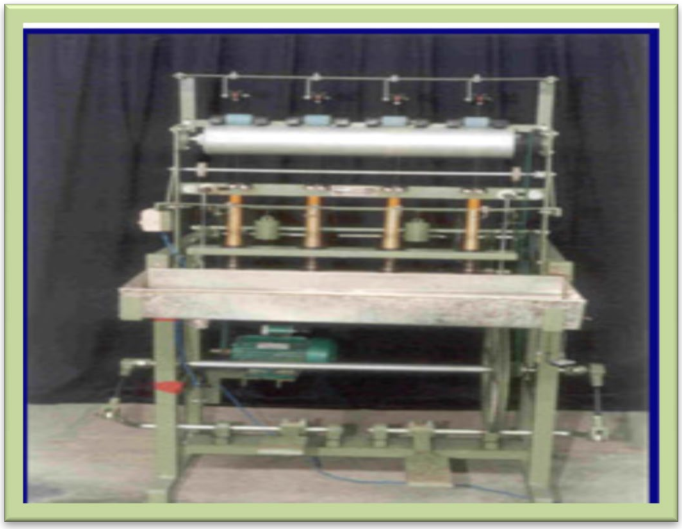

Fig 6.9 Motorized Muga/Tasar reeling cum twisting machinE

Salient features of technology:

- Most popular and versatile reeling machine widely used in muga and tasar silk reeling.
- Reeling and twisting of reeled silk done simultaneously.
- The production of the reeling machine is about 250 gms/8 hours.
- TPI of 5 to 9 turns per inch can be imparted on the machine.
- Suitable for both Dry & Wet Reeling of Tasar yarn
- Suitable to twist 2ply yarn
- Suitable to produce Warp Yarn
- Ensures better earning potential to the reeler in comparison with the traditional reeling methodologies.

Kamdhenu- Vertical Reeling-cum-Spinning Machine

- Efficiency Machine is 80 % and weight of new machine is low(20kg).
- Dual option for reeling and spinningfunction.
- User friendly machine, having adjustable spindle speed and perfect yarn deliveryspeed.
- Capacity to reel 200-250cocoons/day/operator
- Better quality of yarn which can be directly used as warp and weft thread to produce handloomfabric.
- It is portable machine and it requires lowmaintenance.

- The machine has been offered to NRDC, New Delhi for commercialization.

Table.1. A trial of Tasar cocoon reeling (K.E. Song, 1967)

Cooking		Reeling	Results
First stage	**Second stage**		
A. Solution (Alum 0.2% formalin 0.05% non-ionic surfactant 0.03%) **Boiling for 30 min.**	B.Solution (NaOH 0.1%, H_2O_2 0.2% non-ionic surfactant 0.03% Soaking for 24 hrs.	**-**Sitting type reeling machine (for Dupion silk reeling) -Reeling cocoon number per thread: 40 pcs.	-Size of thread (Denier) 225 -Weight of reeled silk per reeler: 125.6 gr. /1 hr. -Silk ratio of cocoon: 8.25%.

c) Eri cocoon spinning:

Eri cocoons as they are attached to a peduncle are open mouthed with a discontinuous filament, which make them suitable only for spinning. Approximately 90 percent of Eri cocoons are hand spun in Assam, India. The characteristics of Eri cocoon bave are shown in Table 2.

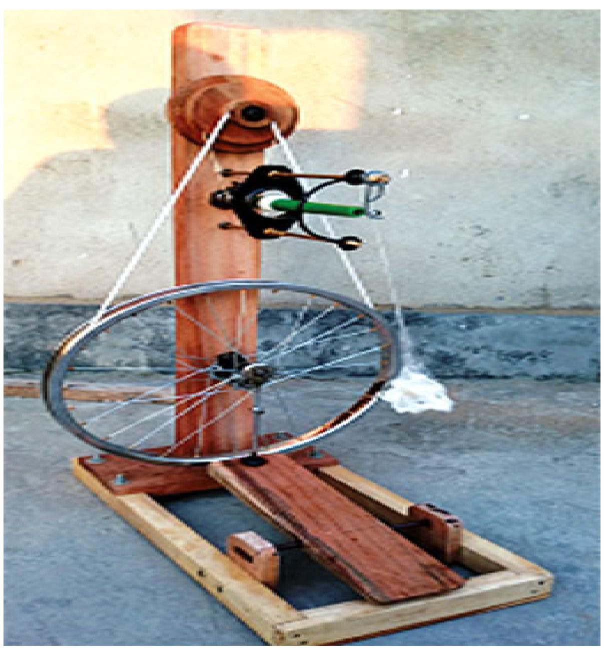

Fig 6.10 Eri silk spinning wheel

Takli spinning

The Takli consists of a spindle with disc like base. The spinner holds the cocoon cake in the left hand, drafts and then feeds the strand with the right hand to the spindle. The spindle is occasionally rotated by the right hand in order to wind the yarn to the spindle. Production is around 40-60g/ person/days.

Improved spinning wheel

Although the Takli is very simple and cheap, its output is quite low. Improved spinning devices have been developed time to time in which CSTRI spinning wheel is the latest one. The production is around 120-150g/ person/ day with 70-80% recovery from the cocoon shell.

Table.2 Characteristics of Eri cocoon and bave

Cocoon	Cocoon bave	Composition of bave
Weight (g): 2.4-2.6	Size (denier): 1.77	Fibroin (%): 72.2
Shell ratio (%): 13	Tenacity (g/d): 3.5	Sericin (%): 11.9
Length (mm): 3.5-5.5	Elongation (%): 20.8	Fat (%): 1.3
Width (mm): 14-25		Moisture (%): 14.6

(source**:**A survey B.H. Choe, et.al., 1969**)**

- The cocoons are at first boiled in an alkaline solution containing soap and soda, with the object of removing the gum. Otherwise spinning is not possible.
- This is done by loosely warping the cocoon in a piece of cloth, and dipping them into the vessel containing the solution. When the cocoons have been sufficiently boiled, they are taken out and washed in cold water several times to remove the solvent.
- The cocoons are then squeezed until a large part of the water is removed before being spread out and dried for spinning.

The appliances commonly used for spinning are takli and common charka. Recently improved equipment with treadle mechanism and automatic traverse motion has been developed, and is used for spinning. About 20 to 30 gm of yarn can be spun per a day. The Eri spun yarn is white and lustrous and on an average the yield of yarn is about 50-60 percent of the weight of the cocoons.

6.10 SUMMARY

- Reeling or unwinding of silk cocoon is carried directly or indirectly.
- Reeling is a technical and skilled job performed by a trained person.
- Depending on the required denier the required numbers of baves are taken from standard size of raw silk.
- The jettebout is aimed to maintain regularity of size and continuity of silk thread. Threader (Country charka), porcelain button (cottage basin) and jettebout are used in improved reeling-units.
- Intertwining of silk baves is technically called as croissure.
- There are chambon and tavellette type croissures where former is primitive later one is advanced and universally accepted.
- The reels are aimed to draw off the baves-from the cluster of cocoons to help in forming a continuous thread and to wind up itself the thread of raw silk produced.
- There are small reels, standard reel and primitive reels.
- The silk thread coming from croissure has considered amount of water which affect the quality of silk. The excess water is removed using traverse.
- Grant reeling is to make a particular size, pattern and number of webs across the face of the hank.
- The defects of reeling such as short lengths of fine sizes, broken threads, entanglements, hard gum spots, short lengths of loose threads are rectified in re-reeling, while reeling on to a standard reel of re-reeling machine.
- The re- reeled silk is visually examined to remove dirt and other defects after opening the ribbings.
- The cleaned silk hank is opened into five parts, laced and tied with silk or cotton threads. The two ends are tied with colour threads while colour is used to identify ends and Denier..
- Skeins are made by twisting the hank and folding at the centre. This is made to give a flower or fiacco crown.

- The skeins are made into books and bails. Each bale contains 133 lbo r 60 kg.weight.
- From Tasar and Muga cocoons silk is reeled by reeling machines.
- From Eri cocoons silk thread is extracted through the process of spinning.
- Softening of non-mulberry cocoons is elaborate process, it is done by boiling in alkaline solutions for longer durations.

I. Short Answer Type Questions

1. Define reeling.
2. What is direct and indirect reeling?
3. Mention types of threaders.
4. Define rosett.
5. Define balloon.
6. What is the importance of jettebout?
7. Mention types of Croissures.
8. What is the purpose of croissure?
9. Write the sizes of reels.
10. What is the importance of reel?
11. What is the purpose of traverse?
12. Define re-reeling.
13. What is the purpose of silk examination?
14. Define lacing.
15. Where do you use colour threads in lacing?
16. Define skeining.

19. What is fiacco crown?
20. Define book and bale?

II. Essay Answer Type Questions

1. Discuss about the reeling operations briefly.
2. Write about country Charkha reeling.
3. Discuss about Cottage basin reeling.

4. Discuss about Multi end reeling
5. Discuss about Automatic reeling machine.
6. Discuss about reeling water.
7. Write about detailed process of re-reeling.
8. Write short notes on a) Silk examination b) Croissures c) Standard reel
9. Write short notes on a) Lacing b) Book making c) Jettebout
10. Write short notes on a) Reels b) Storage of silk c) Improved charkha
11. Write about Tasar cocoon reeling.
12. Write about Eri cocoon reeling.
13. Write about Muga cocoons reeling technic.

Ψ

UNIT 7

RAW SILK TESTING

Structure

Learning Objects:

After studying this chapter student will be able to

- Know the importance of raw silk testing
- Know the methods of testing
- Understand the Parameters of silk testing
- Know the standard Appliances for testing
- Know the classification of the raw silk

7.1. Introduction

In any industry it is necessary to test the end product before it is being used by other industry or the public. The silk (raw silk) is tested and graded as per the standard methods before marketing. It is beneficial to the reeler and also weaver. It was made mandatory in sericulture advanced countries like China and Japan. In India Silk Conditioning and Testing Houses have been established at only few places. These centers also find actual mercantile weight of raw silk by subjecting the raw silk to a process known as conditioning or desiccation.

This industry requires machines, technical man power and quality raw material. Further reeling of cocoons is an artistic occupation. In this process the yarn of at least 10-12 cocoons are processed to form a raw silk yarn for further processing in the weaving industry. Silk weaving has reached a very high standard of industrial efficiency. In fact, today a number of varieties of silk fabrics are produced on handlooms and sophisticated power looms. This requires different qualities of raw silk. In order to assist the weaving industry in the selection of the required raw silk, it must be first tested and classified. Further, the raw silk reeling industry requires well-defined standards, which can only be achieved by silk testing. As the demand for silk is global and a number of countries compete in the trade of raw silk, it is necessary that there should be industry standards for raw silk quality so as to enable buyers to purchase raw silk at internationally accepted grades. This is the reason why all raw silk produced should be classified following testing.

The testing of raw silk is based on the procedure laid down by the International Silk Association (I.S.A.). This procedure is quite conservative and the equipment used is consistent with traditional patterns when compared to procedures followed for general textile products. The traditional method has been widely preferred in silk producing and consuming countries of the world. The mechanical testing procedure is similar everywhere, but the compilation of test results and standards for various grades differs slightly from country to country.

In 1914, an essay competition was held in New York for quality silk goods. During 1921-1927, silk classification committees were set up. In 1928 and 1929, International Technical Conferences were held in Yokohama and New York, respectively. All silk producing countries such as Japan, China, Russia, France, Italy, etc., and silk consuming countries such as the United Kingdom and the United States, were represented. The organization of the International Silk Association and the organization of the third International Technical Raw Silk Conference in Zurich in 1949 followed by a fourth one in New York in 1950, contributed to placing silk technology and silk research on a global basis. In 1949-1950, a Bulletin was issued by the International Silk Association (I.S.A.) on International Standard Methods for Raw silk Testing and Classification. In 1961 a revision was made and it was decided to divide them into three categories. A second amendment was made in raw silk testing and classification in 1974. Recently, an electronic testing system was introduced into I.S.A.'s methods.

Two main tests are usually applied, namely the conditioned weight test and the test for quality. The quantity tested from a consignment depends on the total weight. Usually, 5-10 bales of 60 kg each or 20 bales of 30 kg each is the unit of testing used for the export of raw silk.

7.2. Testing methods and parameters

7.2.1. Parameters Concerned to Silk Quality:

a) Raw Silk

It is understood to be a continuous thread from beginning to the end of the skein. This thread is reeled from several cocoons.

b) Skein

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

c) Denier (D):

As per International agreement made in a conference in Paris in 1900 a weight equal to 0.05-gram Silk thread is known as denier. The size of the thread is indicated by the weight of a 450m skein in denier (0.05gm or 9000m. thread weight 1 gm).

d) Standard Condition:

It is the condition in which raw silk contains moisture equivalent to 11% of the absolute dry weight of raw silk.

e) Standard Bale:

It indicates 60 kg or 132.3lb weight of raw silk. This unit is called a Picul.

f) Standard Atmosphere:

Relative humidity 65% (±2) and temperature 25°C (±2)

8.2.2. Testing Methods:

There are two categories.

A. visual
B. mechanical tests.

A. Visual Tests

The raw silk is tested visually to determine

i) Uniformity of colour, luster and feeling

ii) Condition of general finish and

iii) Nature of the lot.

The visual test is very important from the point of view of grading. In this test all the books and skeins in lot are taken as a test sample. All the visual tests are conducted in a standard visual inspection room. The room should have a window directly facing north to enable full utilization of sunlight, free from the reflection of any surrounding object. If not, artificial light can also be used for visual test.

The visual test examines the

- Reeling defects i.e. hard gum spots, gummed skeins, irregular traverse, double ends.
- Finish defects i.e. improper lacing, dropped threads, disturbed traverse, loose end, double ends.
- Makeup defects i.e. irregular skeins, improper skein twisting, raised threads, cut ends, streaky threads, and gum knots on skeins, foreign matter on skeins.
- Damage defects i.e. friction damage, insect-eaten thread, dis-coloured skeins, soiled thread, deformed books, gummed books are identified which are intern used to grade the silk.

B. Mechanical Tests

It includes the following tests.

i. Winding test

ii. Size test

iii. Evenness variation test

iv. Cleanness test

v. Neatness test

vi. Tenacity and elongation test

vii. Cohesion test

viii. Conditioning of Raw silk.

i. Winding Test

In winding process the silk thread from skein is transferred to bobbin. The weaver winds these skeins to the bobbins for making warps and wefts for weaving. This process indicates brakes, knots, which are loss to the buyer, further it increases production cost. This winding test favours to estimate the probable number of breaks in a given unit of silk. The skein is first conditioned in a standard atmosphere for two hours before winding. After conditioning the test samples, skeins are rubbed gently to soften all the gum spots. These are mounted on to the swifts. Then traverse motion winding machine is adjusted according to the length of the bobbin. After then skeins are wind with specific speed as per the denier shown below.

Denier	Filature Silk/ Charka in meters
12 D or below	110/ 90
13 to 18 D	140/ 110
19 D and above	165/ 140

ii. Size Test

The size of raw thread is given by the weight expressed in denier (1denier = 0.05 gm) of samples of 450 meters of thread. These small skeins are commonly called as sizing samples, are prepared by hand reels or motorized winders. This method favours to find-out the average size, standard size deviation and maximum size deviation expressed in Denier for all classes of raw silk. In order to know how much length of raw silk contains a specific weight contains, the average denier/size of raw silk is determined.

Maximum size deviation and standard size deviation is expressed by the higher of the two differences i.e. the difference between the average size and average size of a known number of the coarsets skeins, and the difference between the average size and the average size of the same number of the finest skeins. The standard size deviation is expressed by the square root of the quotient obtained by dividing the sum of frequency of the deviation of the individual observed size values from the mean by the number of observations.

Average size = Arbitrary mean + FD x class interval

N

Standard size deviation = (FD)2 (FD)2

__________ X class interval

N N

Maximum size deviation=Average of four coarse skeins - Av. Size------------- (1)

Average of four finest - Av. Size------------------------ (2)

Higher of (1) or (2) will be the maximum size deviation.

For filature silk of 33 denier or below, 200 test skeins each of 450metres length at the rate of 4 test skeins from each of 50 bobbins from the test sample. For 34 denier or above, 400 test skeins of 112.5 mts. Skeins from each of 50 bobbins for the test sample.

For charka silk of 33 denier or below, 40 skeins each of 450 meters length at the rate of 4 skeins from each bobbin from the test sample. And for 34 denier or above, 80 skeins each of 112.5 meters length at the rate of 8 skeins from each of 10 bobbins from the test sample.

iii. Evenness variation Test

This parameter indicates the uniformity of thickness of raw silk thread in a longitudinal direction. If the silk thread of uniform thickness is used in weaving with fixed number of picks and ends will not show any thick and thin strips. Generally uneven thick raw silk results when varying number of cocoons are used per end.

This is examined by using Seri-plane. The panels of Seri-plane boards are prepared and placed in the dark room/inspection room. After illumination of side lamps silk thread is examined by standing two meters away from the panels. For filature silk 100 panels and for charka silk 20 panels are assessed by comparing with standard photographs.

iv. Cleanness Test

Sometimes defects like waste, large slugs and corkscrew appear in the raw silk due to defective cocoons and cocoons of indigenous silkworm races. It may happen with improper cooking of cocoons also. Besides these improper casting of cocoons, careless knotting in reeling and re-reeling operations defects like bad cast and long knots appear in the silk thread.

These defects sometimes are large prominently visible on the cloth. Depending FD2 N (FD) 2 N on the defects there are three classes of cleanness defects. They are super major defects, major defects and minor defects. Super major defects are those which are mentioned above. The major defects are as follows.

Waste: A mass of tangled cocoon filament or fiber.

Large Slugs: Considerable thickened places in the thread which are 2-7 mm in length.

Bad casts: Abruptly thickened places in the thread due to the cocoon filament not being properly attached to the thread or adding of more than one cocoon filament at a time.

Heavy corks crews: Places in which one or more cocoon filaments are longer than the rest and give the appearance of a very thick and large spiral form.

Very long knots: They have loose ends of 10mm and above in length. The above said defects with reduced dimensional size are called minor defects. The preparation for testing is similar to evenness test using Seri plane. After illumination stand in front of the rack at a distance of above 0.5 meter for assessing 100 panels for filature silk and 20 panels charka silk.

v. Neatness Test:

There are small defects which are classified as detailed below.

Fine corkscrew: Places in which one or more cocoon filaments are longer than the rest give the appearance of a final spiral form.

Hairiness arid Fuzziness : The condition of the raw silk thread which shows small, loose ends less than 10 mm in length and fine particles of cocoon filaments projecting from the thread.

Loops: Small open places in the thread due to excessive length of one more cocoon filament Less than 100 in length.

Knots: Small tick end places or spots in the thread less than 2 mm length.

vi. Tenacity and Elongation Test

The tenacity of raw silk is indicated by the load which the silk thread can withstand just when it breaks in relation to its size/thickness. The tenacity value is expressed in terms of grams/denier. The elongation property is indicated by the ratio of the length of the silk threads stretched to the point of breakage to the original length of the test sample expressed in percentage. The silk thread has an elongation of 20-25 per cent in standard atmospheric conditions.

Serigraph machine is used to find out tenacity and elongation test values. This machine has a device of stretching the thread at a specified speed of 15cms/minute. Further it records the load at the breaking point in the graph as well as the calibrated scale. The silk thread normally has a tensile strength of 3 to 3.5 grams per denier. These tests require standard atmosphere conditions (65±2% relative humidity, 27±20°C temperature).

Each sizing skein is then tested for tenacity and elongation using the serigraph, which is placed in the room under the same standards of humidity. The tenacity is expressed in grams per denier, while the elongation is expressed in percentage of total stretch of the portion tested. The result is indicated by the average results of ten sizing skeins. The result of tenacity is calculated by omitting the figures after the second decimal.

vii. Cohesion Test

As we all know that silk filament consists of fibroin (the fiber part of silk) and sericin (the gum covering the fiber). It is the sericin causes loops of the cocoon filament to stick together in the cocoon. When these cocoons are boiled for reeling, the sericin is softened and partly dissolved.

This factor allows the silk filament to be pulled off in one length by a process known as reeling. These filaments coming from several cocoons collectively from the raw silk thread.

The sericin dries on exposure to the air and causes the filaments to agglutinate. This agglutination enables the filaments to withstand the friction during the process of weaving. The cohesion test determines the degree of cohesion of cocoon filaments forming the thread expressed in terms of strokes. The cohesion property depends on cooking of cocoons, formation of croissure, length of croissure and speed of the reeling machine.

This parameter is calculated with the help of Duplan Cohesion tester. It has 10 hooks on each side of the frame and under a constant and uniform tension of 180 grams the silk thread is subjected to friction at 20 different places simultaneously. Further it records the number of stokes automatically.

viii. Conditioning of Raw Silk

Since silk fibre is highly hygroscopic it is necessary to subject it to conditioning before transaction. This prevents fraudulent transaction in marketing. In the conditioning oven raw silk is dried at 110 C. This equipment has suspended balance to record the weight of the skeins with an accuracy of one centigram. The following formula is used to calculate the conditioned weight of the test skeins.

$$W = W1 + \frac{W1 \times 11}{100}$$

Where W = conditioned weight of the silk in gm

W1 = oven dry weight of the test skeins in gm

7.3. Standard testing appliances

7.3.1. Winding Frame

It is used to conduct winding test, loading the bobbins and capable of being adjusted to a speed of 110, 140 or 165 m per minute. It should be equipped to drive the bobbins from both ends and run smoothly at uniform speed. The swifts weight about 530 gm and automatic in the their movements. The bobbin dimensions should be 60 mm head, 38 mm barrel, 85 cm length between heads, weight 105 gm (Fig 7.3.1).

7.3.2. Sizing Reel

The skeins are made using a reel of 1.125 m circumference (400 revolutions will yield 450 m of thread) and capable of revolving at a uniform speed of 300 RPM, provided with a dial showing the number of revolutions. It is provided with stop motion to stop the reel in case of thread breaks. Epprouvette is equipment having almost same arrangement except automatic stop device and is used for single cocoon reeling (Fig 7.3.2).

7.3.3. Balance

It is to find out the total weight of sizing skeins and should have a sensitivity of 5 mg and a capacity of 50 gm.

7.3.4. Denier Scale

It is used for weighing the sizing skeins, and has the capacity and sensitivity as shown below (Fig. 7.3.1).

Capacity Sensitivity

40 deniers - 0.25 deniers; 80 deniers - 0.5 deniers;160 deniers - 1.5 deniers

400 deniers - 2.5 deniers

7.3.5. Seriplane

It is used to conduct evenness tests, cleanness tests, and neatness test. The standard photographs are used for comparing the actual samples taken on inspection board. This is conducted in a special room known as inspection room. The inner walls of the room are painted with amt pale grey paint. The floor and ceiling should be in white. The viewing panel is fixed on inspection rack. The boards are fixed to revolve on two central pivots. The lighting is arranged with two vertical reflectors with chromium reflecting surfaces, corrugated and shaped so as to produce a diffused light of uniform distribution. Each reflector is 152.5 cm long and fitted with six 50 watt bulbs.

Scriplane is designed to rotate on Inspection Board and Silk threads of fixed length can be wound upon it with uniform speed (100RPM). It is provided with an indicator to show the number of raw silk threads wound on the panel. Seriplane can accommodate ten filled bobbins which are wound on ten different panels or black boards. Panel is section of raw silk 127 mm wide by 450 mm long, uniformly wound from a bobbin on to an inspection board. Inspection board is a flat black, with uniform surface and one meter circumference.

7.3.6. Serigraph

It is a tensile strength testing machine to record simultaneously the elongation of the thread. The distance between the upper and lower clamps is 10cm and the pulling speed of the lower clamp is 15 cm per minute (Fig. 7.3.5).

7.3.7. Cohesion Tester

It consists of a framework to place raw silk thread between a set of ten hook on each side of the frame under constant and uniform tension so as to subject friction at twenty different places simultaneously. The number of strokes is recorded automatically (Fig. 7.3.6).

7.3.8. Conditioning Oven

It is drying (at 1400C) raw silk under controlled conditions. It has a balance to weight the skeins. Besides this boil-off kettle, modified seriplane, platform scale, stop watch, weighing box are also required (Fig 7.3.7).

7.4. Classification of Silk

In India the ISI (Indian Standard Institution) (1964) recognizes silk into three classes, Class-I, Class-II and Class-III, the first two includes filature and charka silk respectively and the third not falling in either of the two.

Fig 7.3.1 Wrap reel

Fig. 7.3.2 Eprouvette

Fig. 7.3.4 Denier Scale

Fig 7.3.5 Seri plane winder

Inspection board

Standard Photographs

Fig.7.3.6. Serigraph

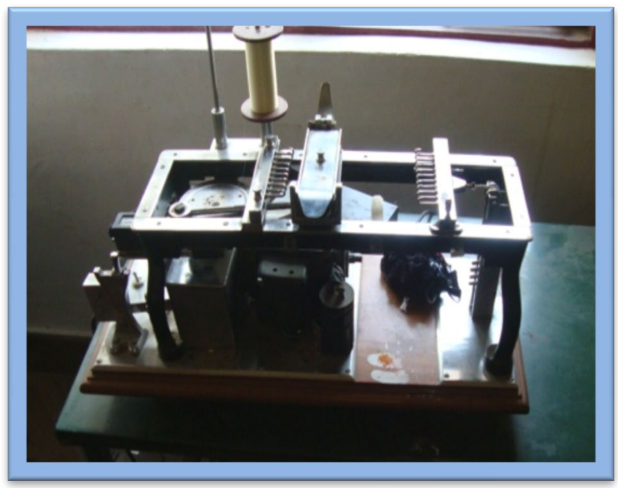

Fig 7.3.7 Cohesion tester

Fig 7.3.8 Condition oven

7.4.1. Raw Silk classification

The silk classification is based on evenness, cleanness and neatness supported by size deviation, strength, elongation and winding. The advantages of testing and classification are as follows.

- Finds out the correct mercantile weight of raw silk.
- Quality ensures equitable transaction between seller (reeler) and purchaser (weaver).
- Certificate of quality issued by the organization is acceptable to all.
- It reveals the preference to the purchaser for particular quality raw silk.
- Investigations conducted at the testing and conditioning organization would lead to evolving remedial measures to avoid reoccurrence of defects in rearing and reeling.

The silk shall be divided into three categories according to their size. 1st Category - 18 denier and below 2nd Category - 19 to 33 denier 3rd Category - 34 denier and above Their grades are expressed in the order of 4A, 3A,2A, A,B.

Method of classification:

i. Grading according to major tests

The 33 denier and finer categories are graded according to lowest percentage of size deviation, evenness variation I, Evenness Variation II, Cleanness. Average neatness and Low neatness. The 34 denier and coarser are graded according to lowest percentage of size Deviation, Maximum

Deviation, Evenness Variation I, Evenness Variation II, Cleanness, Average neatness, Low neatness.

ii. De-grading according to Auxiliary Tests Any one values of Maximum Deviation, Evenness, Variation III,Winding, Tenacity, Elongation or Cohesion indicates silk grade.

S.No.	Tests (Auxiliary)	Value	Grade
1.	Maximum Deviation Evenness Variation-III, winding test, Tenacity, Elongation or Cohesion for 33 denier and finer thread .	Low values any one test class & actual class	Between Auxillary
2.	**Evenness Variation-III,** Winding, Tenacity Test for 34 denier and coarser thread	-do-	-do-
3.	Auxiliary tests	Two more values	declared to the lowest
4.	(General Finish) Winding Test (Skein Finish Inspection)	Test class Slightly inferior Poor	below to proceeding Test class Poor
5.	Visual Inspection	Inferior No breaks	B GRADE
6.	**Winding Test Low value**	**Exceed limits**	
	Low value	**No.of breaks**	
	12 Denier or finer	50	
	13 to 18 Denier	40	
	19 to 33 Denier	35	
	34 to 69 Denier	25	
	Coarser	10	
7	**Average size variation:**	**Size** 20/22 Denier or finer	**Variation** 4% either way

		21/23 to 26/28 Denier 27/29 and Coarser	3.5% either way Unless a special agreement, the Average size shall fall within the Size limit.

Raw Silk Grading 19 D to 33D

Major items	Grade	4A	3A	2A	A	B
Size Deviation (denier)	19 d. - 22 d	1.15	1.35	1.60	1.95	above 1.95
	23 d. - 25 d.	1.30	1.50	1.80	2.20	above 2.20
	26 d. - 29 d.	1.40	1.65	1.95	2.35	above 2.35
	20 d. - 33 d	1.50	1.75	2.05	2.50	above 2.50
Evenness Variation I (count)		150	170	190	210	above 210
Evenness Variation II (count)		10	17	26	37	above 37
Cleanness (%)		97	95	93	88	below 88
Average Neatness (%)		94	92	90	87	below 87
Low Neatness (%)		90	87	83	77	below 77
Auxiliary	Class	(1)	(2)	(3)	(4)	(5)
Maximum Deviation (denier)	19 d. - 22 d.	3.1	3.6	4.3	5.3	above 5.3
	23 d. - 25 d.	3.5	4.1	4.9	5.9	above 5.9
	26 d. - 29 d.	3.8	4.5	5.3	6.3	above 6.3
	30 d. - 33 d.	4.0	4.7	5.5	6.8	above 6.8
Evenness Variation III (count)		0	1	2	6	above 6
Auxiliary	Class	(1)	(2)		(3)	(4)
Winding (breaks)		4	10		18	above 18
Auxiliary	Class	(1)				(2)
Tenacity (grams)		3.7				below 3.7
Elongation (%)		18				below 18
Cohesion (strokes)		60				below 60

Source: FAO manual on Sericulture

7.5 Summary

- Classification of raw silk is beneficial to the reeler and weaver.
- Silk classification is based on evenness, cleanness, and neatness tests.
- This classification favours to find out exact mercantile weight of raw silk.
- It is important to know about the parameters concerned to silk quality i.e. raw silk, skein, denier, standard condition, standard bale, standard atmosphere.
- The visual test examines the reeling defects, finish defects, makeup defects, damage defects.
- Mechanical test examines winding, size, evenness, cleanness, neatness, tenacity and elongation, cohesion, conditioning parameters of raw silk.
- Winding test examines to estimate the probable number of breaks in a given unit of silk.
- Size test is to find out the average size, standard size deviation and maximum size deviation of all classes of silk.
- Evenness variation test is for finding uniform thickness of raw silk.
- Cleanness test finds out defects like waste, large slugs and corkscrew in the raw silk.
- Tenacity of silk thread is indicated by the load the silk thread can stand just when it breaks.
- Cohesion test determined the degree of cohesion of cocoon filaments forming the thread expressed in terms of stokes.
- The important testing appliances used in sericulture reeling industry are Winding frame, Sizing reel, Eprouvette, Balance, Denier scale, Seriplane, Cohesion tester, Serigraph, Conditioning oven.
- Raw silk is classified in to class I,II,III and expressed in the order of 4A, 3A, 2A, A,B.
- Method of Classification is based according to major tests, auxiliary tests, average size variation.

I. Short Answer Type Questions.

1. Mention the advantages of raw silk testing.
2. Define skein.
3. Define denier.
4. Define bale.
5. What are the defects encountered in visual test?
6. Mention some mechanical tests?
7. What is the purpose of winding test?
8. What is size test?
9. What are the tests on seriplane?
10. Mention some major defects of cleanness tests.
11. Mention some testing appliances.
12. Mention the classers and grades of raw silk.
13. Mention method of raw silk classification.

II. Essay Answer Type Questions.

1. Detail about the parameters concerned to silk quality.
2. Write about visual tests of raw silk.
3. Mention mechanical tests. Detail about size test.
4. Write about evenness, cleanness, neatness test.
5. Write in detail about standard testing appliances.
6. Write about classification and grading of raw silk.
7. Write short notes on.
   a) Winding test b) Seri-plane c) pupal waste
8. Write short notes on
   a) Skein b) Sizing reel c) Average size variation.

Ψ

UNIT 8

REELING ECONOMICS

Structure

Learning Objects:

After studying this chapter student will be able to

- Know about the economics of different reeling machines.
- Know about reeling records and its uses.

8.1. Introduction

Reeling industry in India mainly depend on Charkha, Cottage basin and Multi-end reeling machines. More than75% of raw silk produced is only on Charkha. 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. After country charkha cottage basin need further more investment for its establishment and there is a possibility to increase day to day production by adding additional number of basins under one unit like multi end reeling machine. 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 Multivoltine Cocoons. The initial establishment cost and working capital varies from one machine to other. Tabulation and estimation of non-recurring and recurring expenditure of different machines helps to estimate the cost of production of raw silk and its profit. This models of estimation of economics are considered for recording details of different reeling enterprise. Establishment of filature needs a lot of financial investment. And it may be difficult for private entrepreneurs to undertake, an investment of Rs 70-80 lakh are required for the industry of 20 basin units. Recording each and every cost incurred to establish any reeling unit is mandatory for its smooth maintenance and also helps in stabilizing production of raw silk both in quantity and quality wise.

8.2&3. Economics of country charkha and cottage basin

Reeling is a technical, skilled job involving stifling, cooking and unwinding of silk from the cocoons. On an average 10-12 cocoon filaments are made to form a single thread of raw silk. Reeling requires simple technique and can be undertaken on simple machinery. Charka units are very simple, rural oriented and the installation cost is limited. One charka can undertake processing of 10 kg of cocoons and produces 1 kg raw silk in a day. Charka reeling ensures employment for two individuals, one for moving the wheel and other for reeling the cocoons. This kind of reeling would be a suitable economic source to a small family group, where the husband can be involved in reeling activity while the wife can attend to turn the charka wheel. This small family can handle cocoons worth of Rs.2000/- and can earn Rs. 500/- as a wage component per day. Charka reeling would be a very good for self-employment with little investment towards equipment cost. The net return would be 5% per day. However, establishing a 5-charka unit would be economical and better for an individual entrepreneur. Net production and returns may be increased by using improved charkha and Cottage basin with increased number of ends in which facilities like motor operation and a few additional facilities like jettebout and separate cooking unit etc., are developed.

Table 8.1 Economics of country charka and cottage basin

S.No.	Details	Country Charkha	Improved Reeling Machine
1.	Cocoon utilization in 8hrs. (Kg)	10.105	7.791
2.	Raw silk production in 8 hrs. (kg)	1.101	0.837
3.	Renditta	9.17	9.30
4.	Sale of Raw silk (Rs.)	1800.00	2000.00
5.	Income from silk waste @ 60/- per kg.	540.00	540.00
	Total Amount	2340.00	2540.00
6.	**Production Cost**		
	a) Cost of cocoons @ Rs. 200/- kg.	1800.00	1800.00
	b) Labour cost	300.00	300.00
	c) Power	100.00	200.00
	d) Depreciation @ 10% on capital	0.90	3.35
	Total Amount	2200.00	2300.00
7.	Single Day Income (Rs.)	140.00	240.00
8.	Income from 1kg. Raw Silk	140.00	240.00
15.	Highest Income from is improved Reeling machine	---------	100.00
	Energy utilization	15-20%	45-50%

Source model: Information leaflet - 10, CSR & TI, 1989.

Note: Cost given in above table is only a model, may vary from place and season

Table 8.2 Establishment cost of Multi – end reeling machine 10 basins x 10 ends

S.No	Items/Particulars	Unit price Rs/-	Quantity	Total Cost Rs/- South zone
1	Multi-end reeling machinery (10ends/basin, 10 basins)	4,90,000	1	**4,99,800**
2	Circular pressurized cooking m/c/vacuum permeation cookingequipment	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**

Table 8.3 Standard Specifications

Capacity	4BASINS	6BASINS	8BASINS	10BASINS	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**

Norms:

- Raw material: Multivoltine / Bivoltine cocoons
- End product: A / 2A grade raw silk
- By-product: Silk waste and pupae.
- Production rate: 1 kg per basin per shift of 8hours.
- 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 /annum.
- Raw silk production: 10 kg per day; 3 MT /annum.
- Silk waste generation: 2.5 kg per day @ 250 g per kg raw silk; 750 kg per annum.
- Pupae generation:60kg per day@800g per kg cocoons;18 MT per annum.
- Manpower requirement: 20 skilled workers.

Table 8.4 **Estimate of working capital requirement for multi-end reeling units**

S. No	Details	10 basin unit(100 ends)	Details	Price /kg (Rs.)
			Bivoltine cocoons	**275**
1	No. of basins installed	10	Raw silk (2A grade)	**2,000**
2	No. of shift / day (8 hours / shift)	1	Silk waste	**300**
3	Production rate per basin / day kg	1.000	Defective cocoons	**125**
4	Production capacity / day @ 100% utilization (kg)	10.000	Wages per worker / day	**250**
5	Renditta	7.5		
6	Raw material requirement (sorted cocoons)/ day (kg)	75.000		
7	Defective cocoons per kg ofcocoons @ 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**		

Table 8.5 Details of working capital *(Rs.)*

S.No	Details	Holding period (Days)	10 Basin/ unit 100 ends
1	Raw material	25	**5,15,625**
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.

Economics for 25 days production / 10 basins (Multi-end machine)

S. No	Details	Quantity	Cost Rs.
1	Raw silk production/ 10basins/25 Days	10 kg/ basin/day for 25 Days 250 Kgs @ Rs 2000/Kg	5,00,000=00
2	Silk waste	2.5 kg /day for 25 days 62.5 Kgs @ Rs 300/Kg	18,750=00
3	Defective cocoons	3.75 Kg/day for 25 days 93.75 Kgs @ Rs 125/Kg	11,719=00
4	Pupa	60 Kg /day for 25 days 1500 Kgs @ Rs 40 /Kg	6000=00
5	**Total returns/10 basins /25 days**		**5,36,469=00**

8.5.2. Records and Uses

The records are necessary for any organization to enter the details from time to time. These also help the reeler as well as weaver. These records should indicate the details of the following.

i. Purchase of cocoons for reeling and its cost
ii. Weighment and quantity of cocoons purchased
iii. Cocoon stock register
iv. Issue of cocoons for reeling.
v. Silk production (daily)
vi. Production of silk waste.
vii. Stocks of silk yarn.
viii. Inventories of general stocks.
ix. Attendance of labour and staff.
x. Financial accounts including the profit and loss statements.

The reeling industry requires good, dedicated workers. The good entrepreneurship is required to study seasonal trends and market trends, market area, market details for better marketing of cocoons and raw silk. The entrepreneur should keep a check over the production cost which is based on the following.

i. Cost of reeling cocoons
ii. Transport charges on cocoons
iii. Cost of fuel
iv. Cost of power and electricity
v. Labour charge
vi. Management and establishment charges
vii. Capital investments interest charges
viii. Depreciation value
ix. Quality of silk yarn produced
x. Realization value by sale of silk waste, pupa and other by products.

The total expenditure is arrived at by deducting the realization value and then the production cost per unit of silk is calculated. For above all calculations the following records are required.

A. Cocoon Purchase Register

It is to enter the details of quality and quantity of cocoons purchased from different markets. It shows maximum, minimum and average rates, total value of cocoons purchased and assessed renditta for each lot.

B. Cocoon Stock Register

The receipt weight of cocoons, opening balance of the stock, daily purchases, daily uses and closing balance of the day are to be recorded. Every day receipts are to be given on lot numbers to avoid confusion. It is better to keep separate registers for different varieties.

C. Issue Register

Daily issue of cocoons for reeling are entered in this register.

D. Silk Production Register

The daily production details are recorded according to each reeler. The silk yarn of different deniers is also entered. It shows the total production of silk yarn for the day in the unit.

E. Daily Silk Waste Production Register

Every day the raw silk production, varieties of waste silk and its weight produced are entered.

F. Stock book of Silk produced

This register is to enter daily production stocks of silk yarn. The opening balance for different deniers, production and receipts for the day, issue/sales for the day and the closing balance are recorded. The stocks are maintained denier wise.

G. General Stock Register

The information about all the articles about the organization are entered in this registered. The opening balance, number received during the day, number/quantity issued and closing balance for the day are entered.

H. Attendance of labour and staff.

Every day attendance of labour and staff recorded.

I. Fuel stock register

The fuel details such as coal, fire wood, kerosene etc. of the daily purchases, daily issues and the closing balance entries are maintained for different varieties.

J. Financial and Accounts Register

The details of all financial transactions such as receipts and payments, profit, loss, production cost, transport expenditure, miscellaneous expenditure, wages, salaries, perks etc., are entered.

K. By-products register

cThe by-product produce of various levels of reeling are entered. The day wise production, sales and closing balance are recorded.

Summary

- Silk reeling industry economy depends on the production of cocoons and raw silk.
- Silk reeling is mostly depending on cottage industry.
- One charka processes 10 kg. of cocoons to produce 1 kg. of raw silk in a day.
- Reeling is unwinding of cocoons using a simple technique.
- Establishment of filature is costly.
- Reeling records help reeler and weaver.
- There are twelve reeling records useful for reeler and weaver.
- These record all the details of seasonal trends, market details, reeling details, production details, cost details etc.

Short answer questions:

1. What is the production and utilization capacity of charka reeling in a day?
2. What are the important uses of reeling records?

Essay questions:

1. Write about the economics of Country charkha reeling.
2. Write about the economics of Cottage basin reeling.
3. Write about the economics of Multi-end reeling.
4. Detail about reeling records.

Ψ

UNIT 9

Silk Dyeing

Structure

9.1 Introduction

9.2 Types of Dyes

9.3 Degumming and Bleaching

9.4 Methods of Dyeing

9.5 Bye products of reeling

9.6Summary

Learning Objectives:

After studying this chapter student will be able to know…

- What is Dye?
- Classification of dyes.
- Application of dyes
- About Water dyes
- About Acid dyes
- Degumming of Silk
- Dyeing of Silk Yarn

9.1 Introduction

Silk, the natural and animal fiber undergoes into three distinct operations during its conversion from cocoon stage to ready to use fabric stage. Broadly it can be classified as Reeling, Weaving and Finishing or wet processing. Wet processing has vital role in marketing silk in domestic and International markets. Wet processing of silk is possible at two stages i.e. prior to weaving (yarn stage) or post-weaving stage (fabric form).

Raw silk contains two distinct protein components namely fibroin and sericin. Fibroin is the filament part that becomes an ultimate composition of fabric, where as sericin is gummy substance to hold fibroin filament together to form thread during process of spinning. Degumming is the initial process of wet processing to remove sericin. The sericin is essentially removed to make silk fibroin receptive for dye absorption or uptake, impart soft feel and lustrous appearance. Bleaching is the process to remove stains, tints and other colouring matter that is present naturally on silk yarn or fabric. Bleaching process is must for silk material for application of light colour shade or to make it bright white. Silk dyeing is is carried out at two stages, one at yarn stage and other at fabric stage depending on market demand. Most of the wet processing and weaving sectors do not follow proper hygienic methods and do not have any quality standards for the dyestuffs, chemicals and water used in unit leading to poor fastness, strength loss, patchy dyeing, etc. Improper lighting, ventilation, drainage, etc. are other problems associated with traditional wet processing units. There is a need to modernize the process of dyeing. Central Silk Board is playing vital role in providing training in wet processing and establishment of mechanized dyeing units and safe process of traditional dyeing units.

Dyeing is the process of adding colour to textile products like fibers, yarns, and fabrics. Dyeing is normally done in a special solution containing dyes and particular chemical material. After dyeing, dye molecules have an uncut chemical bond with fiber molecules. The temperature and time controlling are two key factors in dyeing. There are mainly two classes of dyes, natural and man-made.

By far the greatest source of dyes has been from the plant kingdom, notably roots, berries, bark, leaves and wood, but only a few have ever been used on a commercial scale. Dyes are applied to textile goods by dyeing from dye solutions and by printing from dye pastes.

Dye

A **dye** is a colored substance that has an affinity to the substrate to which it is being applied. The dye is generally applied in an aqueous solution, and requires a mordant to improve the fastness of the dye on the fiber.

Both dyes and pigments appear to be colored because they absorb some wavelengths of light more than others. In contrast with a dye, a pigment generally is insoluble, and has no affinity for the substrate. Some dyes can be precipitated with an inert salt to produce a lake pigment, and based on the salt used they could be aluminum lake, calcium lake or barium lake pigments.

Direct application

The term "direct dye application" stems from some dyestuff having to be either fermented as in the case of some natural dye or chemically reduced as in the case of synthetic vat and sulfur dyes before being applied for better absorption by fibers.

Direct dyes, a class of dyes largely for dyeing cotton, are water soluble and can be applied directly to the fiber from an aqueous solution. Most other classes of synthetic dye, other than vat and surface dyes, are also applied in this way.

The term may also be applied to dyeing without the use of mordants to fix the dye once it is applied. Mordants were often required to alter the tint (colour) and intensity of natural dyes and improve colour fastness.

Chromium salts were until recently extensively used in dying wool with synthetic mordant dyes. These were used for economical high color fastness dark shades such as black and navy. Environmental concerns have now restricted their use, and they have been replaced with reactive and metal complex dyes that do not require mordant.

Yarn dyeing

There are many forms of yarn dyeing. Common forms are the at package form and the at hanks form. Cotton yarns are mostly dyed at package form, and acrylic or wool yarn are dyed at hank form. In the continuous filament industry, polyester or polyamide yarns are always dyed at package form, while viscose rayon yarns are partly dyed at hank form because of technology.

9.2 Types of dyes

Substances that add colour to textiles. They are incorporated into the fiber by chemical reaction, absorption, or dispersion. Dyes differ in their resistance to sunlight, perspiration, washing, gas, alkalis, and other agents; their affinity for different fibers; their reaction to cleaning agents and methods; and their solubility and method of application.

Different Types of Dyes

Various classes and types of dyes are listed below:

1. Acid Dyes
2. Natural Dyes
3. Basic (Cationic) Dyes
4. Synthetic Dyes
5. Direct (substantive) Dyes
6. Disperse Dyes
7. Sulphur Dyes
8. Pigment Dyes
9. Mordant Dyes
10. Vat Dyes
11. Reactive Dyes

9.2.1 Water quality parameters for wet processing of silk:

Various qualities of water badly affect wet processing of silk fabrics. The parameters like colour of water, turbidity, Iron content, total hardness etc, affects the process of degumming and dyeing.

All the above contents of water can be softened by using water softening agents or de-mineralization of water as discussed in 'Reeling water' chapter 6.

9.3 Degumming:

Degumming of silk is process to remove the gum called sericin from silk fibroin. Sericin is soluble even in cold water but with the process of hydrolysis of sericin with acids, alkalis or enzymes breaks down large protein molecules in to smaller fractions making soluble in hot water. Both acids and alkalis damage sericin and fibroin. Their fore degumming in presence of soap solution in presence of mild alkalis like soda ash is predominantly used. The pH of bath should be maintained between 9.5 to 10.5. Raw silk yarn is boiled in hot water with added alkali to remove gum and make them open and soft. The following chemicals are used for degumming.

Standard recipe for degumming:

Chemicals:

1. Material to liquor ratio (M.L ratio) – 1: 30
2. Soap - 5 gr/lit or 15% of material weight
3. Soda - 1 gr/lit or 3% of material weight
4. Time period - 45 minutes
5. Temperature - 95 ° C
6. pH -9.5 to 10.5

Method:

Degumming is the process of removing the sericin, or silk gum, from silk. Removing the gum improves the sheen, color, hand, and texture of the silk. Because the gum can serve as a protective layer, it is typically left on the silk until it is ready to dye. In some cases, the fabric is woven to completion, and then degummed, to protect the yarn from jam on the loom.

Note: Most commercial silk yarns are sold fully degummed, but some dyers still prefer to degum it. Silk which has to be degummed is taken in the form of skeins.

i. Skiens are wetted in soft water for few minutes.
ii. For every kg of silk yarn 30 lt water, 30gr Soda ash and 150gr neutral soap is required
iii. All the above contents are taken and mixed in wide mouthed big vessel and allowed to dissolve by boiling.
iv. At boiling point silk yarn to be degummed is added and continued for 40-45 min.
v. Later skien is taken out from the vessel and washed carefully in soft water.
vi. After degumming left over gum or color is removed by rinsing the yarn in bleaching.

Bleaching:

Bleaching process helps to natural colour pigments completely to make yarn or fabric into pure white material. Chemically, reducing or oxidizing agents are used for silk bleaching. Few important reducing agents used are viz: Sodium hydro sulphite (Hydrose), Sulphurdioxide, Sodium/ Zinc sulphoxylateformaldhyde. Popular oxidizing agents are Hydrogen peroxide, Potassium permanganate, Sodium perborate and Sodium peroxide. The chlorine based bleaching agents like bleaching powder, Sodium hypochlorite are not generally used, as they tend to chlorinate the silk fibroin.

An efficient bleaching process must ensure to maintain pure and permanent whiteness of bleached material. Process should ensure level-dyeing properties otherwise over bleaching or under bleaching adversely affects dye absorption properties of the material lead to degrading and may loose tensile strength and durability of material.

Hydrogen peroxide recipe for bleaching:

1. Material : Water ratio - 1:30
2. Hydrogen peroxide (30%) - 6 gr/ lit
3. Sodium silicate - 1.5 gr/ lit

4. Soda ash - 0.5 gr/lit
5. Temperature - 89° C
6. Duration - 2 Hrs

Note: Wash thoroughly with cold water after process.

9.4 Methods of Dyeing Silk yarn:

Dyeing process is complicated process, which should be conducted very carefully. For dyeing silk yarn so many types of dyes are used like acid dyes, acid milling dyes, basic dyes, metal complex dyes, reactive dyes and direct dyes. Naturally extracted dyes from plants, flowers, tea powder, roots also used. More than 80% of silk yarn is dyed before weaving process, but the cloth weaved by bleached yarn may be printed with colours after weaving.

Dyeing with acid dyes:

Acid dyes can be easily applied on silk and therefore are largely used for dyeing. They are applied generally in the presence of an organic or inorganic acid are called acid dyes. They produce wide range of brilliant shades. However, the fastness of dyes depends on its chemical structure and molecular weight.

Acid dyes are generally represented as R-SO3 Na. When an acid dye is dissolved, produce dye anions (R-SO3-) and colourless sodium cations. These dye anions are exhausted on to silk substrate in the presence of acid. Acid dyes are relatively easy to dissolve, but care is necessary to avoid the possibility of un-dissolved particles getting deposited on material.

The require amount of dye is made in to smooth paste using cold water and sufficient amount of boiling water is added to dissolve completely. It is advisable to filter dye solution before adding it to dye bath.

The dyeing is initiated at 40° C and gradually raised to 85° C. Boiling is avoided as its affects luster of silk. Addition of levelling agents like Glauber salt avoids uneven dyeing. Dye bath should contain 2-4% acetic acid and 10 % Glauber salt. After 45 -60 minutes at 85° C, the material is taken out and given cold water wash.

Dyeing with metal complex dyes:

These dyes are water soluble in which chromium is already bound by co-ordinate valencies and are called metal complex dyes. Their fastness to wet treatment is very good when compared to acid dyes. There are two types one is one atom of chromium associated with one dye molecule and another is associated with two dye molecules called 1:1 metal complex dye and 1:2 metal complex dye.

The dyeing is carried out in a bath containing dye solution of 4-6% ammonium sulphate and 10% Glauber salt and is continued for 45-60 minutes at 85° – 90° C. The material is then taken out and given cold wash.

Reactive Dyes:

Reactive dyes react with fiber molecules to form a chemical compound. These dyes, they are either applied from alkaline solution or from neutral solutions which are then alkalized in a separate process. Sometimes heat treatment is also used for developing different shades. After dyeing, the fabric is washed well with soap so as to remove any unfixed dye. Reactive dyes were originally used for cellulose fibers only, but now their various types are used for wool, silk, nylon, acrylics and their blends as well.

They are classified as Procion dyes (mono-chloro or dichloro triazine dyes) and Vinyl sulphone dyes depending on reactive system of dye molecule. They are further classified as cold brand and hot brand reactive dyes. Dyeing temperature for cold brand dye is 50°-55° C and for hot brand 60°-65° C. Liquor ratio should be 1:30 under neutral conditions. Glauber salt is added as pe requirement exhaust the dye in to fibre. Remaining process is similar to above method.

Direct (substantive) Dyes:

Direct dyes colour cellulose fibres directly without the use of mordants. They are used for dyeing wool, silk, nylon, cotton, rayon etc. These dyes are not very bright and have poor fastness to washing although they are fairly fast to light.

The dye stuff powder is first pasted with cold water and a small amount of soda ash and boiling water should be added to the paste with constant stirring to dissolve it. The silk material is then introduced in the dye bath containing dissolved direct dye solution and required amount of Glauber salt at room temperature and gradually raised to 85°-90° C and continued for 30-45 minutes.

Other dyes used are Vinyl sulphone reactive dyes.

After treatment of dyeing, the material is treated with formaldehyde, cationic dyeing fixing agent, copper salts to improve the light and fastness of dyed material.

Topping with basic dyes:

Basic dyes have affinity for direct dyes. When a solution of basic dye is mixed with a direct dye solution, the dyes combine with each other to form a complex that is less soluble. This is called topping a direct dyed material with a basic dye. This produce brilliant shades on silk.

Natural dyes:

The majority of natural dyes are from plant sources – roots, berries, bark, leaves, and wood, fungi, and lichens. Textile dyeing dates back to the Neolithic period. Throughout history, people used to colour their textiles by using common and locally available dye materials. Scarce dyestuffs that produced brilliant and permanent colors such as the natural invertebrate dyes Tyrian purple and Crimson kermes were highly prized luxury items in the ancient and medieval world. Plant-based dyes such as Woad, indigo, saffron,(Woad is a yellow-flowered European plant of the cabbage family). It was formerly widely grown in Britain as a source of blue dye, which was extracted from the leaves after they had been dried, powdered, and fermented. Dye obtained from the woad plant, now superseded by synthetic productsand Madder plant which gives red dye were raised commercially and were important trade goods in the economies of Asia and Europe. Natural dyes are environment friendly

Different Types of Dyeing Machines:

We can classify dyeing machine in the following way.

Types of dyeing machine according to textile material:

A. Fiber dyeing machine

B. Yarn dyeing machine

C. Fabric dyeing machine

According to dyeing process:

1. Open dyeing machine
2. Enclosed dyeing machine

According to material and liquor movement:

1. Material move but liquor does not circulate i.e; jigger
2. Liquor circulate but materials does not move i.e; all package dyeing machine.
3. Both materials and liquor circulate i.e; jet dyeing machine

According to the materials to be dyed:

1. Loose stock form dyeing machine
2. Hank dyeing machine
3. Package form dyeing machine
4. Fabric form dyeing machine

Chemicals required for dyeing:

1. Dye powder of required shade

2. Acetic acid or Citric acid (40%)

3. Glauber salt (Sodium sulphate)

4. Milsoft

5. Synthrapal and Calsolene

pH of the dye stuff should be between 4-6, time required is 45-50 min, temperature is maintained at 85-90° C and ratio of dye and water should be 1:30.

Fig 9.1 Tub / Open bath dyeing **Fig 9.2 Arm dyeing machine**

YARN DYEING FLOW CHART

YARN INSPECTION

↓

WASHING

↓

DEGUMMING

↓

WASHING

↓

BLEACHING

↓

WASHING

↓

DYEING

↓

WASHING

↓

ACID TRATMENT

↓

HYDRO EXTRACTOR

↓

DRYIING

↓

SKEINING

↓

PACKING

NOTE: After degumming or dyeing for removal of water use hydro extractors, do not squeeze or twist the skeins.

Removal of dyes:

If things go wrong in the dyeing process, the dyer may be forced to remove the dye already applied by a process called "stripping". This normally means destroying the dye with powerful reducing agents such as Sodium hydro sulphite or Oxidizing agents such as Hydrogen peroxide or Sodium hypochlorite. The process often risks damaging the substrate (fiber). Where possible, it is often less risky to dye the material a darker shade, with black often being the easiest or last option.

Precautions:

i. During dyeing Safety is most important. When using dyes, always wear gloves, goggles and a particulate mask .When handling the dry dyes, which can be a respiratory hazard.

ii. In case of dyeing use lab glass beakers to measure dye solutions, stainless steel bowls, kettles, and spoons, stainless steel chopsticks for stirring and lifting skeins, and a tiny gem scale to measure dye powders.

iii. The eye dropper is useful for measuring small amounts of dye, or for handling small amounts of the adjunct chemicals. It is important to have dedicated equipment for dyeing - you should not use any of the equipment for food after it's been used for dye.

iv. Never use cast iron, aluminum, or any other reactive metal - it can affect your results a lot, and in some cases also damage the utensils

v. The chemicals used in this process are about as dangerous as laundry detergent. Take appropriate cautions; you may wish to use eye protection, gloves, and a mask. The main caution listed on the packaging of the chemicals, is to avoid getting it in your eyes

vi. The synthetic textile dyes represent a large group of organic compounds that could have undesirable effects on the environment, and in addition, some of them can pose risks to humans.

vii. Up to the present moment, no efficient method capable of removing both the color and the toxic properties of the dyes released into the environment has been found.

Establishment of dyeing unit is best enterprise for self- employment, State and Central Govt. (CSB) is providing subsidized loans for the establishment of dyeing units. The following is the model economics for establishing dyeing unit.

Table 9.1 Model dyeing economics (50 Kg - 2 Arm dyeing Units)

S.No	Particulars	Cost (Lakhs)	Loan	Margin
1	Building	2.25	1.69	0.56
2	Machinery (2 Arm dyeing units, Hydro extractor, water softening plant, Effluent treatment plant and Gen set)	17.00	12.75	4.25
3	Miscellaneous fixed assets	0.40	0.20	0.20
4	Preliminary and pre- operative expenses	1.25	0.63	0.63
5	Contingencies	1.70	-	1.70
6.	Working capital	0.32	-	0.32
Total project cost		22.92	15.26	7.66

Source: Seri business manual, CSB.

Note: With above establishment one can dye 20 Kg raw silk/day-2 shifts, 25,500 Kgs / Year (Capacity- 30000 kgs/ Year) and with the dyeing cost of Rs. 80/Kg, average gross earnings would be 22.00 Lakh rupees / Year. *Costs given are only a model may vary from time to time.*

9.5. By products

The different stages of reeling industry yield various by-products. This comprises cocoons, reeling and re-reeling waste, waste water, pupae. All these are used in various industries and forms a very good source for substantial returns. The sale of by-products to the respective industry reduces the production cost of the silk. The reeling waste are classified as

1. Waste cocoons
2. Cooker waste
3. Reeling waste
4. Re-reeling waste

9.5.1. Waste cocoons

- All types of waste cocoons, floss are used to produce spun silk, the double cocoons are used to make dupion silk and are used in rubber industries.
- The waste cocoon silk is used in carpet and coir industries.
- Pierced cocoons are cut in different shapes and used in preparation of bio-crafts like garlands, flowers, bouquets and decorative items. These items are beautiful and fetching good prices.
- Silk yarn from pierced cocoons is produced by manually operated pedal charka by a process known as spinning after degumming process to remove the sericin.
- Pierced cocoons are also used to produce matka silk or handspun silk in which spinning is carried by hand with the help of takli. This silk is rough in quality and used to produce coarse/thick fabric.
- Hand spinning industry uses pierced cocoons to form silks like ghicha and katia which are used for producing fabrics like gent’s cheddars, lady’s scarves, furnishing cloth and caps.

9.5.2. Cooker waste

- When the cocoons are cooked the cooker waste is obtained while picking the ends and the cocoons are brushed. In this process the upper silk layer is disturbed and peeled off in bunch. This is called cooker waste. This bunch is drawn to a longer size while it is hot and wet.
- Boiled-off-cocoons are discarded at both the cooking and reeling ends. Though cocoons are sorted before cooking for thin ends, holes, stains, flimsiness and pointed ends became waste/unreelable. The dropped cocoons from the cocoon basin during boiling and at the reeling basin during reeling are called boiled-off or burst-open cocoons and commercially called jelly goodu or water joly.

- The overcooked and water-laden due to water entering into the compact shell due to defects and all these cocoons are unreelable. These are used in spun silk production.

9.5.3. Reeling waste

a. Silk thread waste

- The thread waste is generated by the reeler during process of end-finding of the cocoons and also during the formation of breaks and re-joining of the cut ends. This waste is used to make carpets, toys, scarves, ties etc,.
- It is produced from different types of reeling wastes and some unreelable cocoons. It is produced by hand spinning or machine spinning. It is used as spun silk yarn or indirectly as blended yarn by mixing with other natural or manmade fibres.
- The fine quality silk waste like filature wastes, cooker's waste, reeler's waste, re-reeling waste, throwster's waste are of high quality and used in spun silk mills for spinning fine yarn.
- While waste coming from defective cocoon, boiled-off cocoons, palade are used in hand-spun yarn production.
- Among the reeling waste 30-35 percent is used for spun silk and 20-25 percent for noil silk production.

b. Pupae:

- These are found inside the cocoons. The pupae are killed before the cocoons are reeled. After complete reeling of cocoon, the dead pupae wrapped in gossamer/palade layer remain in the basin. These pupae are used in several ways.
- Silkworm pupae have numerous constituents of great food value. The fat alone is about 30 percent of total dry weight.
- First the palade/gossamer layer is removed to utilize the pupa.
- The pupa is rich in protein and fat content and have a very high nutritive value but high water content is drawback. It causes rapid decomposition with emission of a foul smell

- When the silkworm pupae are cooked with rice powder and Leaven is added to the cooked product for quick drying, and for storing for a longer period.
- By adding sugar and water in suitable amounts, the dried material can be allowed to ferment and to develop a good taste.
- In some parts of China, Japan silkworm pupae are used as food. The pupae are cooked in very hot water or roasted. It is a delicacy to tribal's in some parts of north-eastern states of India also.
- The oil is extracted from pupa which contains 35% fat and 50% proteins. This oil contains high amounts of vitamin-A and after deodorization can be conveniently used for human consumption and in making soaps. Further effluents released during the manufacturing of soaps and detergents, glycerin is obtained.
- After oil extraction pupal cake has higher nutritive value than that of beet protein. The pupae as it is (without removing fat content) mixed with poultry feed improves egg-laying capacity. It also improves growth of the hens.
- The fat-free pupae are used to feed the carps and other fishes.
- The pupae are used to feed cattle, besides using in the preparation of dog biscuits, shampoo, tooth powder, chemicals and medicines.
- There is increased demand for bio fertilizers in agriculture. Silkworm litter and pupae are very good source for all kinds of plant nutrients.
- From defatted pupal protein artificial fibres and membranes are made. In addition, peptones are prepared from it.
- Further pupal protein is used as raw material for preparing amino acids and flavoured products with high nutritive value.

c. Palade layer

- It is the last parchment layer of unreelable silk surrounding the pupa which is too thin. It is a broken and cannot be reeled in the normal course.
- Silk waste of residual cocoons from the reeling basin is called as palades. in order to separate the inside pupa from the Palade /gossamer layer silk these are kept immersed in

water for 24-36 hrs and beaten up to squeeze the pupa out and is degummed and stretched to form long, drawn waste.

- The silk remaining is used for hand spinning or machine spinning.
- This used water contains dissolved amino acids and vitamins. Thus, it can be conveniently used for plants after cooling.

9.5.4 Re-reeling waste

- Raw silk waste is obtained during re-reeling and throwster's wastes.
- Re-reeling waste includes defects in the reeled filaments like abnormal thickness, gum spots, spliced ends, and broken threads. During this process some portion of the thread is pulled while picking the end. This silk is a non-twisted silk waste.
- Throwster's waste is found during the process like twisting, throwing, weaving and knitting of the raw silk.
- With an average 100 kg of silk waste, 16 kg of spun yarn and 12 kg of noil silk are produced in the spun silk mills.
- This silk can be used in fabric weaving and also used in packing pencils or puffs for talcum powder.
- Throwster's waste is also used as raw materials for sound free gears. By adding gelatin, casein etc. to squeezed and dried silk fibres, it is possible to increase their oil resistance, acid and heat.
- Silk fibroin is used to prepare natural fibroin creams. It keeps the skin smooth, delicate and improves the shining. Further it is also used in shampoo preparation

Summary:

- A **dye** is a colored substance that has an affinity to the substrate to which it is being applied.
- The dye is generally applied in an aqueous solution, and requires a mordant to improve the fastness of the dye on the fiber.
- Synthetic dyes quickly replaced the traditional natural dyes. They cost less, they offered a vast range of new colors, and they imparted better properties to the dyed materials.

- Dyes are now classified according to how they are used in the dyeing process.
- **Acid dyes** are water-soluble anionic dyes that are applied to fibers such as silk, wool, nylon and modified acrylic fibers using neutral to acid dye baths. Acid dyes are not substantive to cellulosic fibers. Most synthetic food colors fall in this category. They are normally sold as the Sodium salt, therefore they are in solution anionic.
- Animal protein fibers and synthetic nylon fibers contain many cationic sites.
- Anthraquinone derivatives generally form blue dyes.
- Azobenzene derivatives generally form red dyes.
- Triphenylmethane derivatied generally form yellow or green dyes.
- **Azo dyes**: The structure of azo dyes is based on azobenzene. Although azo dyes are a separate class of dyestuff mainly used in the dyeing of cotton (cellulose) fibers, many acid dyes have a similar structure, and most are red in color.
- Degumming is the process of removing the sericin, or silk gum, from silk. Removing the gum improves the sheen, color, hand, and texture of the silk.
- During dying Safety first. When using dyes, always wear gloves, wear goggles and a particulate mask when handling the dry dyes, which can be a respiratory hazard. Once they are wet in solution, they are not as dangerous.
- By products of reeling industry posses food industrial values so as to get good self employment in the rural areas which inturn improves rural economy.
- Spinning is a process where pierced cocoons are used to produce silk yarn, using pedal charkha.
- Matka / hand spun silk is also produced from pierced cocoons.
- Boiled-off cocoons are used to produce spun silk.
- Silkworm pupae have high nutrient value and used as food by human beings in China, Japan.

Short Answer Type Questions

1. What is dye? write few precautions during dyeing.
2. How many types of Dyes are there?
3. What are natural dyes?
4. Mention types of dyeing machines.
5. Mention few assistive chemicals used in dyeing process.
6. What is Degumming?
7. Mention recipe contents for degumming.
8. What is bleaching?
9. What is an acid Dye?
10. What are the safety measures to be followed during dyeing?
11. Mention by-products of reeling.
12. What are the uses of pierced cocoons?
13. What is matka silk?
14. Define reeling waste?
15. Mention some uses of silkworm pupa.
16. Define Palade.

Long Answer Type Questions

1. Write about different types of dyes.
2. Explain about Degumming process.
3. Write about process of bleaching.
4. Write briefly about dyeing of Silk yarn.
5. Write about classification of dyes.
6. Bi products of reeling waste are best source of self-employment" discuss.
7. Write short notes on
   a) Uses of Pupa b) Waste Cocoons. c) Dupion silk

GLOSSARY

Bave: Technical name of silk filament spun by silkworm. The two brins coming from two silk glands are made into one filament at spinneret.

Cocoon These are spun by silkworm larvae as a protective covering for undergoing pupation. It has raw silk shell as well as pupae.

Dupion silk The silk which is produced by reeling double cocoons.

Flimsy Cocoons There are defective cocoons which posses' very thin shell consisting little amount of silk.

Palade layer After spinning compact shell of the cocoon the shrinking larva wraps itself in palade or gossamer layer and detaches itself from the shell to undergo pupation. This layer is very thin and un- reelable.

Renditta It is the number of cocoons required to produce one unit of raw silk.

Seri plane It is an instrument used to find out uniform thickness of raw silk thread in a longitudinal direction. It also indicates cleanness, neatness.

Spun silk Silk produced from different types of unreelable cocoons.

TakliAn instrument to carry on spinning process using hand.

Kakame Standard cost of cocoons required to reel one kg of raw silk.

Cocoon Sorting A methodical and technical separation of good and bad cocoons.

Fibroin It is one the silk protein secreted by posterior part of silk gland. It forms the fibrous part of silk bave.

Sericin It is a gummy layer formed over the fibroin. It is a protein secreted by middle part of silk gland.

Reelability Suitability of cocoons for economic reeling with which the cocoon yield silk bave

Grain or Wrinkle The rough surface of cocoon. Find granular surface is better for good reeling.

Eprouvette It is equipment used to measure filament length of a single cocoon.

Denier Size of the silk bave.

Shell Ratio The ratio between cocoon and shell. It indicates the amount silk.

Floss The outer most loosely knit, fragmented unevenly thick silk layer of cocoon.

Button This is an apparatus which is made of porcelain material, rounded one which makes agglutination between the baves of cocoons while reeling process and avoid the basic slugs.

Jettebout It is an instrument invented by Serrel American engineer in France it is used to make casting of the bave around the thread.

Croissure Making a spiral around a thread on croissure wheels to avoid excess of water and improved cohesion of thread.

REFERENCE BOOKS

1. Silk Worm Rearing, Volume-2-15/2, FAQ of United Nations,Rome, 1987.
2. Appropriate Sericulture Techniques,ManjeetS.Jolly, CSRTI,Mysore, 1987.
3. Hand Book of practical sericulture, Ullal&Narsimhanna, CSB,Bangalore, 1981.
4. Hand Book of Silkworm Rearing, Tazima, Agriculture TechnicalManual-1, Fuji Publishing Co. Ltd., Japan, 1992
5. Techniques of Silkworm Rearing in the Tropic, ESCAP, UnitedNations, New York, 1993.
6. New Illustrated Sericulture Reader, CSB, Bangalore, 1997
7. New Technology of Silkworm Rearing, S. Krishnaswamy,CSRTI, Mysore.
8. An Introduction to Sericulture, Ganga &Sulochana Chetty,Oxford & IBH Publishing Co. (P) Ltd., New Delhi, 1995.
9. Principles of Sericulture, HisaoAruga, Oxford & IBH PublishingCo. (P) Ltd., New Delhi, 1994.
10. Pattuparishrama (B.Sc.), P. Srinivas *etal*., Telugu Akademy,Hyderabad, 1996.

11. Pattuparishrama (Intermediate), P. Srinivas, Telugu Akademy,Hyderabad, 1996.

12. Text Book of Tropical Sericulture, Japan Overseas Co-operationVolunteers, Japan, 1975.

13. A Practical Guide to Mulberry Silk Cocoon Production,Krishnaswamy, Bangalore, 1994.

14. Sericulture Instructional Cum Practical Manual, Vol.II, NCERT,New Delhi,1990.

15. Bulletins on Sericulture, C.S.B., Bangalore.

16. Hand Book on Agriculture, ICAR, New Delhi, 1992.

17. Hand Book on Pest and Disease Control of Mulberry and Silkworm,ESCAP. United Nations, Thailand, 1990.

18. Silk in India, Statistical Biennial, C.S.B., Bangalore,1992.

19. Lecturers on Sericulture by Boraiah, SBS Publishers, Bangalore,1994.

20. Global Silk Secnario-2001 by CSB, Oxford & IBH Publishers,Bangalore, 1996..

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SERICULTURE

II YEAR

PART-B, VOCATIONAL COURSE

PAPER-I THEORY

Seri – Biotechnology & Farm Management

Periods/Week :04 **Periods/Year:110**

Time Schedule Weightage And Blue Print

S.No	Name of Unit	No.Of Periods	Weightage In Marks	Short Answer Questions	Essay type Questions
1	**Seri Bio-Technology– Introduction, Basics of Plant and Silkworm Bio-Technology, Importance of breeding in Mulberry and Silkworm, Tissue culture. Sericulture Research and Development Institutes in India.** ,	15	18	2	1
2	**Cytology and anatomy of mulberry** – Introduction, Structure of cell, cell organelles Mitosis and meiosis Cell division, **Genetics, Mendal Laws**, Anatomy of leaf, stem and root	20	2	1	1
3	**Farm Management-** Introduction, Mulberry farming, raising saplings in nursery bed, Integrated weed management, labor management, farm records.	5	8	1	1
4	**Mulberry Diseases** – Introduction, Fungal, Bacterial, Viral diseases	20	10	2	1

	and Nutrient deficiency diseases and its control and remedial measures grainage registers /records.				
5	**Mulberry Pests** – Introduction, Lepidopteron pests, Jassids, Thrips, Mites, Beetles, **Integrated Disease and Pest Management (IDPM)**	20	10	2	1
6	**Estimation of Leaf Yield** – Introduction, methods of estimation **in various plant spacing systems.**	5	6	1	1
7	**Raising and maintenance of chawki garden-** Introduction, importance and package of practices. .	10	8	--	1
8	**Economics of Mulberry cultivation** – Introduction, **Economics of Nursery, Rain- fed cultivation, irrigated cultivation, vermin- compost ,** Economics of 1 acre irrigated and rain-fed Mulberry	15	8	1	1
	TOTAL	**110**	**68**	**10**	**8**

SERICULTURE

II YEAR

PART-B, VOCATIONAL COURSE

PAPER-II THEORY

Silkworm Seed Technology

Periods/Week :05 **Periods/Year:110**

Time Schedule Weightage And Blue Print

S.No	Name of Unit	No.Of Periods	Weightage In Marks	Short Answer Questions	Essay type Questions
1	**Systematic Position of *Bombyx mori*** – Introduction, Systematic position and classification, types of Silkworms. ,	5	8	1	1
2	**Morphology and life cycle of *Bombyx mori*** – Introduction, study of life stages and cycle, sex differences in larva, pupa and moth, metamorphosis.	15	10	2	1
3	**Parental Races** – Introduction, Distribution, seed organization, races, Voltinism, moultinism, **breeds/hybrids in current use.**	15	8	1	1
4	**Grainage Equipment** – Introduction, Prerequisite of Grainage, Grainage model building, equipment and uses, disinfection, grainage registers /records.	15	8	1	1
6	Seed Production – Introduction, preperation of layings, Sheet eggs, loose eggs, mother moth	20	8	1	1

	examination, Surface sterilization, assessment of layings and incubation of eggs.				
7	Acid treatment and hibernation schedules – Introduction, types of eggs, physical and chemical stimulants, types of acid treatment and hibernation schedules of eggs.	10	10	2	1
8	Seed Economics – Introduction, economics for 10 lakhs seed capacity	10	6	--	1
	TOTAL	110	68	10	8

SERICULTURE

II YEAR

PART-B, VOCATIONAL COURSE

PAPER-III THEORY

Post Cocoon Technology

Periods/Week :05 **Periods/Year:110**

Time Schedule Weightage And Blue Print

S.No	Name of Unit	No.Of Periods	Weightage In Marks	Short Answer Questions	Essay type Questions
1	**Silk Reeling Industry** – Introduction, importance of reeling industry, scope and limitations.	10	8	1	1
2	**Cocoon Quality and Cocoon Sorting** – Introduction, physical and commercial characters, properties of silk, Principles for assessment, Tactile and Numerical Tests, Good cocoons, Defective cocoons, model problems, model problems.	15	10	2	1
3	Cocoon Marketing – Introduction, Rules and Acts, Price Fixation, model problems .	5	6	--	1
4	**Cocoon Stifling** – Introduction, Stifling methods, storage of cocoons, ushnakoti, sorting of cocoons, de flossing, Riddling, mixing.	15	14	1	2
5	**Cocoon cooking and Brushing** – Introduction, Reeling water, cooking and methods of cooking, Brushing and methods of Brushing	15	10	2	1

6	Reeling-Introduction, Reeling apparatus and Machines, Reeling water, re-reeling , Silk Examination, Lacing and skeining, making of skeins , book making and baling, **Spun silk making** and Non-mulberry cocoon reeling.	15	10	2	1
7	**Raw Silk Testing**– Introduction, Testing Methods, Parameters, Standard Testing appliances, Conditioning of Raw silk, classification of Raw silk.	10	2	1	1
8	**Reeling economics- Introduction,** Economics of Charaka, cottage basin and **multi-end** **reeling machines,** reeling records and uses.	15	8	1	1
	Silk Dyeing – Introduction, Types of Dyes, Degumming, methods of dyeing. Bye products of Reeling	10	2	-	1
	TOTAL	**110**	**68**	**10**	**8**

SERICULTURE
II YEAR
PAPER I Seri – Biotechnology & Farm Management

TIME: 3 Hours **Max. Marks: 50**

SECTION-A

Note: i) Answer all Questions.
ii) Each question carries 2 marks **10x02=20**

1. What is Tissue Culture?
2. What is cell division?
3. **Define Bio-Technology**?
4. Importance of farm records.
5. Leaf spot disease.
6. Nitrogen deficiency
7. What is pest?
8. Write control measures for Jassids (Leafhoppers)
9. Importance of spacing in Mulberry plantation.
10. Importance economics?

SECTION-B

Note: i) Answer any 5 Questions
ii) Each Question Carries 6 marks **5x6=30**

11. Explain the preparation of Tissue culture media.
12. Explain in detail about Mitosis.
13. Write about different weeds and Integrated Weed Management in mulberry.
14. Mention causative agent, symptoms Powdery mildew and suggest few control measures.
15. Write about Bihar hairy caterpillar on mulberry.
16. Write the procedure for leaf estimation.
17. Explain importance and package of practices for chawki garden
18. Write short notes on
    a) Vermi compost b) IDPM c) Tukra

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SERICULTURE

II YEAR

PAPER II Silkworm Seed Technology

TIME: 3 Hours **Max. Marks:50**

SECTION-A

Note: i) Answer all Questions.
ii) Each question carries 2 marks **10x02=20**

1. Write the classification of *Bombyx mori.*
2. Define Metamorphosis.
3. What is Voltinism?
4. Name any four Grainage equipments and its uses.
5. Name the stages in the life history of *Bombyx mori.*
6. What is Synchronization?
7. What is Coupling and de-coupling of moths?
8. What is the aim of moth examination?
9. What are the types of eggs?
10. Name the Acid and equipment used in Acid treatment.

SECTION-B

Note: i) Answer any 5 Questions
ii) Each Question Carries 6 marks **5x6=30**

11. Describe the Systematic position of *Bombyx mori.*
12. Explain the morphology of Silkworm Larva.
13. Write notes on the Parental races of Silkworm.
14. Explain any five Grainage equipments and uses with a neat labeled diagram
15. Explain briefly Grainage operations in a commercial Grainage.
16. Explain the preparation of loose eggs.
17. Write about Hot acid treatment of Bivoltine eggs.
18. Write short notes on
a) Voltinism b) Expand UV, BV, MV & CB c) Transportation of eggs.

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SERICULTURE

II YEAR

PAPER III Post Cocoon Technology

TIME:3 Hours **Max. Marks:50**

SECTION-A

Note: i) Answer all Questions.
ii) Each question carries 2 marks **10x02=20**

1. Name some Silk fabrics.
2. What is Shell Ratio?
3. Mention four defective cocoons.
4. What is Stifling?
5. What is size of cocoon?
6. What is cocoon brushing?
7. What is Ahimsa silk?
8. Define baling of Silk.
9. Reeling records?
10. What is degumming

SECTION-B

Note: i) Answer any 5 Questions
ii) Each Question Carries 6 marks **5x6=30**

11. Write in detail about scope & limitations of Reeling Industry.
12. Explain in detail about commercial characters of cocoons.
13. Explain about Rules and Acts of Cocoon marketing?
14. Write about hot air drying and its advantages and disadvantages.
15. Write about Three pan cooking method.
16. Write about Multi-end reeling operation.
17. Write standard methods of Raw silk testing.
18. Write Short notes on
    a) Value addition b) economics of cottage basin c) Silk dyeing

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