

AET.201 Introduction to Sericulture and Apiculture (2+1)

Lecture -1

Introduction to Sericulture and its scope

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 whereas, Non mulberry silk is called Vanya silk.

Three main branches of Sericulture are:

1. **Moriculture** (Mulberry cultivation) - Host plant cultivation, mainly Agronomic aspects.
2. **Silkworm rearing**- has two branches- Grainage technology (egg production) and Silkworm rearing (larval stage management)
3. **Silk Reeling and weaving**- Industrial aspects, cocoon onwards.

What is silk?

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

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”

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
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

IMPORTANCE OF SERICULTURE

1. Agro-based cottage industry with very high employment potential with 60 lakh persons engaged in sericultural activities.
2. Provides vibrancy to village economies. Share of income to various groups are as follows:
 - a) 56.8 % to cocoon growers (Silkworm rearers)
 - b) 6.8% to reelers
 - c) 9.1% to twisters
 - d) 10.7% to weavers
 - e) 16.6% to traders

Large chunk of **income goes back to villages** from cities.

3. Low gestation and high returns. It's a low volume, high value crop.
4. Highly women friendly occupation as 60 % of women are engaged in sericulture.
5. It's an ideal programme for weaker sections of the society.
6. It's a very eco-friendly activity.
7. Sericulture earns foreign exchange (>2000 crores) and silk items are exported to over 50 countries.
8. It satisfies equity concerns as money flows from high end groups to low end groups. Users belong to higher economic groups.

Distribution and statistics of silk production in the world

Sl no	Country	Production in MT	%Share
1	China	84000	81.06
2	India	16322	15.75
3	Brazil	811	0.78
4	Thailand	665	0.64
5	Vietnam	550	0.53
World Mulberry raw silk production		1,03627 MT	

STATE WISE PRODUCTION OF MULBERRY AND VANYA SILKS IN INDIA

STATE	MULBERRY SILK
VANYA SILK (MT)	

	Plantation (Ha)	Raw silk (MT)	
Tasar	Eri	Muga	

A. TRADITIONAL

Karnataka	77329	7238	-
-	-		
AP	33325	4492	
13.0	7.0	-	
TN	13345	1411	-
-	-		
WB	15563	1809	
31.23	11.23	0.20	
J&K	7065	102	
0.01	-	-	
MP	1114	96	
30.14	4.0	-	
Maharashtra	4504	200	
4.28	-	-	

Manipur		6108		96		3
24.0	0.60					
Mizoram		5725		9		0.1
6.0	0.2					
Meghalaya		918		2		-
435	12					
Nagaland		400		2		0.5
160	0.50					
Orissa		285		4		
57	8.5	-				
Punjab		653		4		-
-	-					

B. NON TRADITIONAL

Assam		4756		15		-
1141	105					
Arunachal Pradesh		211		4		0.10
14.0	0.5					
Bihar		449		9		16
2	-					
Chhattisgarh		624		5		147
1.5	-					
HP		738		22		-
-	-					
Jharkhand		79		1		296
0.1	-					
Kerala		1525		20		-
-	-					
Rajasthan		230		1		-
-	-					
Sikkim		189		1		
-	0.5	-				
Tripura		780		8		-
-	-					
Uttar khand		1179		17		
0.5	1.4	-				
UP		831		42		
4.15	5.78	-				

STATISTICS SHOWING RECENT TREND IN INDIA

Year	Mulberry area		Mulberry	Raw silk		Total	
	Vanya	GrandTotal		BV/	MV	Tasar	
	(Ha)		(M.T)				
	Eri	Muga	Total				
2007-08	1.84		1175	15070	16245	428	1530
	117	2075	18320				
2008-09	1.77		1250	14360	15610	603	2038
	119	2760	18370				
Change*	-3.8		6.4	-4.7	-3.9	40.9	
33.2	1.71	33.0	0.				

Lecture-2

COMMERCIALY EXPLOITED SILKWORM SPECIES

There are four kinds of natural silks which are commercially known. The term silk generally refers to mulberry silk. Three other commercially important silk falls into the category of non mulberry silk which is also called Vanya silk.

Different species of silkworms

Bombycoidea comprises of eight families of which, two namely **Bombycidae** and **Saturniidae** are commercially important.

The Mulberry silkworm belongs to Family Bombycidae and the silk produced is called Mulberry silk. The insect producing mulberry silk is *Bombyx mori*.

The commercially exploited mulberry silkworm belongs to Family Bombycidae. It is domesticated and has been exploited for over 4000 years. *Bombyx mori* is believed to have been originated from *Bombyx mandarina* – the wild ancestor of commercially cultivated silkworm. *B. mori* is classified into Japanese, Chinese, European or Indian based on geographical distribution. Depending upon number of generations produced in a year, they are classified as univoltine, bivoltine and multivoltine. Based on the number of moults they are classified as tri moulters, tetra moulters and penta moulters. It is also classified in to pure strains and as hybrids which may be monohybrid when only two strains are involved or poly hybrids when more than two strains are involve in hybrid. *Bombyx mori* produces cocoon with continuous filament and therefore can be industrially reeled to produce raw silk.

Family Saturniidae is also commercially exploited and consists of Tasar , Eri and Muga silkworms.

The commercially exploited ones are:

Antheraea pernyi-----Chinese Tasar

Antheraea mylitta -----Indian Tasar

Antheraea yamamai –Japanese Tasar silkworm

Antheraea assamensis -----Indian Muga silkworm

Philosamia ricini or currently named *Samia cynthia ricini* — Eri silkworm

Sarcophagous fauna belong to the Family Saturniidae (Super family Bombycoidea), are mostly wild silk moths. Wild silk moths include tasar silkworm, oak tasar silkworm eri silkworm and muga silkworm. Tasar silkworm is classified as Chinese, Indian and Japanese. Most important is Chinese tasar *Antheraea pernyi* which are either uni or bivoltine and their silk can be reeled as mulberry raw silk. Chinese and Japanese tasar feed on oak leaves and other allied species and Indian tasar feeds on *Terminalia* and several other minor host plants. (Also see Laboratory Manual, provided at the end)

Eri silkworms :

Two species namely *Philosamia ricini* Hutt and *Philosamia cynthia* Drury are exploited. *Philosamia cynthia* is a currently named *Samia cynthia ricini* and commonly called **castor silk worm**, is domesticated producing white or brick coloured silk. Since filament of cocoons is neither continuous nor uniform in thickness, it cannot be properly reeled and so moths are allowed to emerge naturally and then silk is used. It is also called **Ahimsa silk**.

Tasar silkworm

Three species of *Antheraea* are exploited for production of silk known as tasar silk or Vanya silk. *Antheraea mylitta* (= *Antheraea paphia*), Tropical tasar (*A. pernyi*) and Temperate oak tasar, *A. proylei* are cultured in India, mainly by tribals.

Host plants: Insect is polyphagous and has Primary and Secondary host plants (Refer Laboratory manual)

Non mulberry silkworm rearing:

TASAR CULTURE

Silkworms show three types of voltinisms, univoltine and bivoltine occur in Central India and bivoltine and multivoltine in north eastern India. Its Holometabola, having four stages in life cycle (Egg, larva, pupa (enclosed in cocoon) and adult (moth). Emergence of moth take place in the evening, the males fly long distance in search of females (which are tied to a straw bundle called KHARIKA) and placed on host trees so that wild males may couple with females ensuring proper mating. Copulation period is for eight hours. The females are decoupled and kept in bamboo baskets (called MONIA) for 2 days to lay eggs. 150-200 eggs are laid. The eggs are oval and dorsoventrally

flattened, having two brown lines running along the periphery and coated with gummy substance. The larvae hatch in about 10 days after eggs are laid. The eggs are kept in leaf cups of host and distributed uniformly on host trees. Larval period is 30-35 days undergoing four moults and has five instars which feed voraciously. When all host leaves are defoliated, silkworms move downwards of the host to find new hosts trees. JALI (a triangular structure is fixed on base of host, so such larvae are collected and transferred manually to other trees with leaves. The normal tasar silkworm at final instar is generally green in colour with violet tubercles distributed over the body and weighs 50-60gm and 12.5-15 cm in length. The matured larvae first spin a kind of hammock by webbing together a few leaves of the host plant. Then it constructs a ring made up of silk to attach the future constructed cocoon to tree twig, in-between it forms a peduncle which attaches the cocoon to the ring. Completely constructed cocoon is large, compact and the bivoltine variety is used for commercial purpose. The bivoltine cocoons are harvested in Nov –December, go into diapause at the pupal stage and the moth emerge in May –June of the following year. Hence, upon cocoon harvest a thick thread is passed through the ring to form cocoon garlands, which are sold. Few to be retained for next rearing are hung indoors during diapause, on moth emergence; females are tied to kharika and hung in jungles for mating with wild males. Rearing is completed in June- July. This is summer crop and the cocoon does not undergo diapause.

The Chinese tasar silkworm, *Antheraea pernyi*, feeds on *Quercus* or oak trees is usually bivoltine and sometimes univoltine. Diapause is always in pupal stage.

MUGA CULTURE

Muga silk is the monopoly of India, culture is not seen in any other part of the world.

Muga is an Assamese word which indicates the brown(amber) colour of cocoon or golden yellow. Muga silk is secreted by semi domesticated multivoltine species. Muga larvae feeding on *Litsea citrate* produce a kind of silk which is favoured for its durability, lustre and creamy white shade.

The golden silk produced by the muga silkworm, *Antheraea assamensis* found only in Assam India. This is semi domesticated. Muga silkworm is multivoltine in nature and therefore rearing could be conducted all through the year. It is polyphagous, feeding on mostly som (*Machilus bombycina*) and soalu (*Listea polyantha*). Only larval stage is wild and spent in open, ripening worms are brought in indoors for cocooning. Mature worms are collected from base of

trees on structures called CHANDALI (Triangular bamboo sieves with long handle). Cocoons have rudimentary peduncle which does not allow attachment to host.

Moth emergence is in the evening, pairing is in the tray itself. Next morning, mated females are separated and placed in egg basket called MONIA, for egg laying. The muga silk worm is multivoltine and passes through four moults and five instars. Moth lays 150-200 eggs.

The tribal takes the Monia with eggs and hang them on host plant in the forest/ jungles. When the leaves are fully consumed, the silkworms climbing down the tree trunks are collected on Chandali, and hung on hosts with leaves. The larval period is 30-35 days. The ripe worms come down the trunk of the tree during the evening at night. They are then collected and put in baskets containing mango twigs which act as a cocoon age for spinning. Spinning take place two to three days and is golden or light brown 4-6cm long 2-3cm broad with rudimentary peduncle. Muga culture is often hazardous and risky on account of attack by several kinds of pests and predators. Constant vigilance is required.

ERI CULTURE

Among the commercially exploited non mulberry silkworms, the eri silkworm, *Samia cynthia ricini* Boisduval is the only species domesticated completely and adopted to indoor rearing all through the year. Eri silk is considered as poor man's silk. Eri silkworm is polyphagous and rearing on leaves of castor, *Ricinus communis* L, alone can ensure good quality cocoons. About 25 percent of total leaf yield can be harvested and used for eri cocoon production without affecting castor seed yield. The female moth lays between 300-500 eggs. Eri silkworms are hardy and not easily susceptible to diseases. The fertilized female moth is tied with a piece of thread to kharika for egg laying. The Eri cocoons are open mouthed and do not contain continuous filament and hence are not reelable. Takli spinning is practiced for eri cocoons. The larval period is 22-28 days, depending upon the host plant.

Eri silkworms are reared following tray method, or branch feeding method wherein branches of Castor leaves are brought indoors and placed in containers with water, to keep leaves fresh.

Rearing of Eri silkworm for cocoon production is not yet followed in Karnataka. Mostly practiced by tribals in North eastern India. Tribals are known to

consume the larvae/pupae. Castor can be cultivated for Eri culture as well as seed production, as capsules are harvested and sold.

The eri silkworm are of two species namely *Philosamia ricini* Hutt and *Philosamia cynthia* Drury . *The latter* is a wild species now named *Philosamia cynthia ricini* and commonly called **castor silk worm**, is domesticated producing white or brick coloured cocoons .Since filament of cocoons spun by these worms is neither continuous nor uniform in thickness it cannot be properly reeled and therefore the moths are allowed to emerge naturally and then silk is used. It is called **Ahimsa silk**.

Lecture-3

Importance of mulberry cultivation

Cultivation of mulberry is the most important factor in rearing of silkworm. Nutritive value of mulberry plays a very effective role in producing good quality cocoons. Silkworm obtains the entire nutritional requirement from mulberry leaves. The insect is monophagous and can complete the life cycle only on mulberry leaves.

Improved mulberry varieties

Name of the variety	Year of release	Parents	Yield	Situation
Kanva2/ M5	1970	Selection from open pollinated hybrid of Mysore local.	30-35 MT/ha in Irrigated . Rain fed 12-15 MT/ha	Both for irrigated and rainfed
MR2	1980	Popular in Tamil Nadu belonging to <i>Morus sinensis</i>	30-35MT/ha under irrigation	Both for irrigated and rainfed condition. A powdery mildew resistant variety
S30		Through chemical mutagenesis (EMS) of Berhampore local	40-42MT/ha	For irrigated and young age silkworm rearing
S 36	1986	-do-	38-45 MT/ha	For irrigated and CHAWKI rearing

S 41		-do-	38-42 MT /ha	For late age silkworm rearing under irrigated condition
S 54		-do-	42-45 MT/ha	-do-
DD(VISWA)	1994	Clonal selection from mulberry plants in dehra dun area	35-40MT/ha 16 MT/ha in rainfed condition	BOTH FOR IRRIGATED AND RAINFED CONDITION
V1 (VICTORY)	1980 -1997	S30XBer776	60-70MT/ha	For irrigated condition. Suitable for rearing both young and adult silkworms.
S13		Selection from Mysore local variety	8-12 MT/ha	for rainfed water stress condition In red soil
S34	1983-1990	S30X Ber 776 Controlled hybridization	15mt/ha	For rainfed black cotton soil for late age rearing
AR-11 Varieties for semi irrigated condition	1986-2004	OPH Selection of k2		Semi arid areas
	197	OPH	35MTtpe rha	FOR SEMI

RFS175	6 198 7	(open pollinated hybrid) Selection of Kanvas-2	under - protected irrigation 45-50MT under irrigated condition	IRRIGATED CONDITION
RFS135		OPH Selection of kanva-2	42MT/HA under semi irrigated condition	For semi irrigated condition
For Specific conditions				
AR12	198 3- 200 4	S41 X Ber-776(2x) Controlled hybridization	25mt/ha	For alkaline condition up to PH 9.5
Sahana	200 4	K 2 x kosen controlled hybridization	25-30MT/ha /yr	Subsidiary crop in coconut plantation
RC1	1987- 2003	PUNJAB LOCAL X KOSEN	25-28mt/ha	50%of the fertilizer

				input and sub optimal levels of irrigation
RC2	1987-2004	PUNJAB LOCAL X KOSEN	25-26MT/H A	50%of the fertilizer input and sub optimal levels of irrigation
G2	1991-2004	<i>M.multicaulis</i> x S34 controlled hybridization	38 MT /ha	Quick sprouting after pruning recommended exclusively for chawki rearing
G4	1991-2004	<i>M.multicaulis</i> x S 13 controlled hybridization	60-70MT/ha/yr	Exclusive for late age silkworms

Selection of planting material

Direct planting of cuttings in the field may result in large gaps. Hence saplings are produced. Saplings are rooted cuttings, about 100-120 days old saplings are used for low or high bush and 240 days old saplings for small trees. Due to well developed root system, saplings get established quickly.

For preparing saplings nursery bed has to be prepared. A flat land near to water source is preferred. The land should be ploughed 30-40 cm deep and allowed to weather in sun for 2-3 weeks. Land is again ploughed to get fine tilth. Root stocks, pebbles and stones are removed. The land is divided in to number of small beds. A bed length of 300cm (L) X 120CM (b) can accommodate 180 cuttings. Row to row spacing of 20 cm and sapling to sapling 8cm distance is required to raise 4 month old saplings. For raising 8 month old cutting row to row 30cm and cutting to cutting 10cm)so the bed can accommodate 100 cuttings. Each bed on all sides are separated by a bund of 25-30cm width and 15^20 cm depth. Add 5 pans of organic manure or FYM. In case of clayey or black cotton soil add sand and in case of red loamy soil there is possibility of termite attack. As a preventive measure add 0.55 chloropyriphos (5ml/ litre of water) can be sprayed to drench the soil of nursery beds (2 to 3 litre per bed).

Cuttings should be 6 to 8 month old and thickness of 10-15 cm diameter. 15-20 cm long with three good buds for 4 month old saplings for 6 to 9 month old cuttings should be 25 cm size, sharp knife should be used to get cleaner edge,

Kissan nursery

Commercial production of mulberry saplings on large scale and make them available to farmers during planting season is called kisan nursery. Nucleus seed is produced in breeding station. From this seed bank of CSB and state level farms, then to seed multiplication centre and to Kissan nurseries.

Another technique is from soft and semi soft wood cuttings, prepare 15 to 20cm long cuttings with one or two top leaves intact and cuttings must be bundled and dipped in 20ppm NAAA for 24 hours. After washing, plant them in nursery bed. Such green wood cuttings are planted in nursery bed, cuttings are planted at 8 to 10 cm distance. Cover the whole bed with polythene sheet. The height at the central portion is 50 to 60cm above ground. Above polythene cover, gunny cloth is spread to serve as sunshade. The ideal temperature is for rooting is 25 to 30 degree centigrade with light intensity of 2000lux. After one month remove shade and apply fertilizer. Bud grafting, layering is also practiced in temperate regions where the scion material is scarce.

Planting

Cuttings should be planted in a slanting position. The soil around the cutting should be pressed immediately. In case of poor rooting variety 200ppm solution of NAA/IBA dissolved in 90% alcohol can be used. Cuttings can be inoculated with VAM (vesicular arbuscular micorhizae) for getting better survivability and economization of phosphatic fertilizer. By this 25 to 50% of phosphate fertilizer can be saved.

Lecture-4

PLANTING: Best planting season is between June-August. Mulberry can be planted either in row system (Kolar system) or pit system. Cuttings should be planted in slant position (45° angle) with one/two eye buds above the ground level. Saplings raised in polythene bags or raised in nursery beds can also be used for planting.

SPACING: Spacing varies depending on the water availability and type of garden. Normally pit system of planting is advocated in view of quality leaf production in irrigated and rain fed conditions. Spacing between the pits is 90x90 cm or 90 x 60 cm. The pit shape is either round or square (30 x 30 x 30 cm).

In row system, the space between rows is 45 cm and between plants is 15cm. Under irrigated condition ridges and furrows are formed for furrow irrigation.

PAIRED ROW SYSTEM

MANURING: Eight to ten tons of well rotten FYM or compost per hectare has to be applied in rain fed conditions and 15-20 tons per hectare under irrigated condition. More FYM should be applied for chawki garden.

FERTILIZERS: Dosage will depend on the fertility level of the soil, type of garden and density of plants. Fertilizers should be applied after six months of planting. The time schedule and quantity of fertilizers to be applied are:

Rain fed crop: N100: P50: K50kg/ha/year.

June- August - 50:50:50 kg/ha (basal dose)

Sept -Nov. - 50 kg/ha (top dress)

There should be sufficient soil moisture at the time of application.

Irrigated crop: N 300: P120:K120 kg/ha/ha

After I harvest 60: 60: 60

After II harvest 60

After III harvest 60: 60: 60

After IV harvest 60

After V harvest 60

Fertilizer application is done in five split doses and each dose is given ten days after harvesting of each crop. Fertilizers should not be applied immediately after harvest and also to the standing crop.

IRRIGATION: The irrigation requirement of mulberry depends on the type of soil and season. In general irrigation is done at five days interval in sandy loam soil and 8-10 days in clay soils.

INTERCULTIVATION:

a. Weeding: As weeds compete with mulberry for nutrients and water, periodically weeding should be done either by hand or by mechanical methods. Weed free condition is very important to prevent the diseases and pests in mulberry. Weedicides, can also be used for weed control. Application of Glyphosphate (glycel) weedicide (2.0kg/hectare, 2% sugar +1%citric acid +500 liters of water) controls many perennial weeds.

b. Mulching: Pruned mulberry branches, sugarcane trash and straw can be used as mulching materials to cover the soil in between rows to conserve moisture and to suppress the growth of weeds. Green manure crops, horse gram, sunhemp, soybean, cowpea are grown as mulch. Mulching material will be incorporated into soil as manure during rainy season.

RIDGING: Ridging between rows in case of row system of planting is to be done after the harvest of every crop to remove weeds, to prevent runoff of water, for easy distribution of water during irrigation and to improve percolation and penetration of water.

KOLAR SYSTEM OF MULBERRY PLANTING:

Shoot harvesting of mulberry is common in Kolar district, under irrigated conditions. Dense planting with a spacing of 30 cm between rows and 10 cm between plants is followed.

Lecture-5

PRUNING

During the productive phase, mulberry plants need to be periodically pruned to keep the leaf production at the highest level. Pruning is the methodological removal of certain branches of the plant with three objectives. 1st objective is to give the plant convenient size and shape, 2nd is to increase the leaf yield and third is to improve feeding value. Mulberry plants are pruned in different ways,

according to climate, geographical conditions and method of silkworm rearing. Pruning of mulberry plants is also useful for adjusting the production period; to synchronize with leaf requirement for silk worm rearing .There for pruning is an important process in mulberry technology. It is a vitalizing process and invigorates plants in to productive phase leading to more luxuriant growth of mulberry leaf. In tropical India, where mulberry sprouts all the year around, pruning season depends upon the rainfall conditions and the method of leaf harvest. Under rainfed condition , the plant is pruned once a year during July to August at a height of 10-15cm from the ground level. This is known as **bottom pruning** .after taking two successive flushes of leaf middle pruning is sometimes resorted to for inducing the sprouting of buds at a height of 60-90cm from ground level. This is called **middle pruning**. In Karnataka two bottom prunings are suggested for pit system, once during **June and second time in November**. This helps in taking five harvests annually.

Step wise pruning is also practiced

Under row system for irrigated mulberry and also in west Bengal in the strip system of cultivation the practice is to cut the whole shoot to the ground level at harvest. Thus, pruning and harvesting of leaves become a combined operation. As there are five crops in a year in Karnataka, there will be five prunings. This system of drastic pruning requires heavy fertilization and irrigation and is practiced in kolar.

For tree plantation the plants are cut at a height of 1-2.5 meter

Leaf harvesting methods

There are three distinct methods of harvesting mulberry leaves viz 1. Individual leaf picking 2.Branch cutting and 3. Whole shoot harvest

Leaf picking:

In this method the leaves are picked individually from the plant. After the leaves are harvested from the main stem, the terminal bud is removed and the axillary bud on the main stem allowed to develop. This results in rapid development of lateral shoots which could have otherwise remained dormant. Subsequently the leaves on the secondary branches are picked as a second crop. When leaves are picked tender leaves are fed to chawki worms

Branch cutting :

In this method the entire branch with leaves is cut and fed to the worms after third moult. In Kashmir it goes by the name batchi system.

Whole shoot harvest:

The advantages of this method are 1.It is easy for operation in low and medium cut bush plantations

2. It saves labour in collection of leaf, distribution of feeds, bed changing and spacing

3. When cut branches are fed, the leaf is utilised to the maximum by the worms

4. Since the branch rearing is practiced on a shelf or on the floor, rearing equipments like trays, shelves etc are not required.

5. It helps in maintaining hygienic conditions in rearing silk worms.

6 .The quality of leaves fed is better as the leaves are attached to the branches and maintain prolonged succulence and freshness.

Whole shoot harvest

This system is practiced in Kolar region of Karnataka and West Bengal for feeding the worms in 4th and fifth stages. The growing top are clipped and

then used for feeding the worms. The whole shoot harvest is done at an interval of 10-12 weeks

Time of harvest

Nutritive value of mulberry is optimum when they are used for rearing silkworms between 30 and 45 days of fertilizer application of fertilizers both in pit and row system of plantation. Fresher the leaf better the feed value. Therefore every effort should be made to harvest quality leaves and also to retain them as fresh as possible. Due to active photosynthesis and transpiration during the day time, leaves harvested late in the afternoon contain comparatively less water and carbohydrates and succulent leaves wither more rapidly than leaves harvested in the morning. It is therefore, recommended to harvest in the morning hours.

Preservation of leaves

During long period of storage, considerable nutritional changes take place in the leaves. The proteins are broken down to amino acids and the carbohydrate to simple sugars in the harvested leaves. These substances are utilized by the leaves for respiration during long duration, in addition to loss of water due to transpiration. Thus, the leaves become poor in their nutritive value. The decomposition of molecules and consequent reduction in their nutritive value are in direct proportion to the changes of in storage and atmospheric temperatures. Transpiration of water is inversely proportional to the relative humidity. The ideal condition is temperature below 20 ° c and relative humidity 90%. Heaping of leaves leads to fermentation and high storage temperature. To avoid this, the leaves should be spread loosely in thin layers and covered with gunny cloth. Leaf storage room must be kept dark as light enhances photosynthetic activity and withering of mulberry leaves.

Storing of mulberry leaves

Fresh mulberry leaves are more palatable and nutritious to the silkworm with wet cloth. The leaves for feeding young worms must be kept in baskets lined with clean wet cloth and also covered with wet cloth. When the leaves are stored in bulk quantities for feeding grown up larvae, they are stored in wooden frames or leaf chambers measuring about 1.5m x 1.0 m x 0.8 which are lined with wet gunny cloth. The leaves should be heaped loosely and should be periodically turned to provide aeration and also to prevent rise in temperature inside the heap of the leaves. Whole cut shoots should be kept in straight position with top ends upwards and covered with wet gunny cloth which should be periodically moistened, especially during summer.

Bio fertilizers in mulberry cultivation

OUT OF many micro organisms which are identified as bio fertilizers, *Azospirillum*, Phosphorus Solubilising Bacteria (PSB) and Vesicular Arbuscular Mycorrhizae (VAM) have a significant role in mulberry nutrition. Integrated use of these bio fertilizers will help in ensuring sustained productivity in mulberry.

Growth stimulation

Azospirillum stimulates mulberry growth and increases the number, length and weight of roots besides bud development. It invades the internal parts of the root and it promotes root hair development and branching. It fixes the atmospheric nitrogen in the roots of mulberry and produces plant growth hormones.

Application of *Azospirillum* at 20 kg/ ha/ yr with well-decomposed farmyard manure in five split doses reduces nitrogenous fertilizer application by 25 per cent.

Innoculation with *Azospirillum* also improves the economic characteristics of silkworm and silk.

It improves larval characteristics (like larval weight, pupal weight, cocoon weight, shell weight and shell percentage) and silk characteristics (like silk filament length and weight of silk).

Role of phosphorus

Phosphorus plays a major role in the balanced nutrition of plants to increase crop productivity. Only water soluble phosphorus is useful for the crop plants.

The availability of phosphorus can be increased by applying phosphorus solubilising bacteria (PSB).

It enhances the phosphorus use efficiency, produces the plant growth promoting substances, and also improves soil fertility and productivity.

The application of PSB at 10 kg/ ha/ yr with well-decomposed farmyard manure in five split doses reduces the quantity of phosphoric fertilizer by 25-30 per cent. Vesicular Arbuscular Mycorrhizae (VAM) is well known for their ability to absorb nutrients from the soil, particularly phosphorus. VAM plays a significant role in nutrient cycling in ecosystem.

The external mycelium extends several centimetres from the root surface and it then passes the depletion zone surrounding the root and exploits soil microhabitats beyond the nutrient depleted area where the small rootlets or root hairs cannot thrive.

Inoculation of VAM either individually or in combination with *Azospirillum* enhances the shoot and root length, number of leaves and the growth of plants.

Combined inoculation

There is an increase in plant height, shoot biomass and leaf weight of mulberry due to combined inoculation of *Azospirillum* and VAM.

The growth substances produced by *Azospirillum* are continuously released from root surface into the rhizosphere where the colony of *Azospirillum* grows with photosynthate supplied by the host plant. Inoculation of *Azospirillum* influences VAM infection of mulberry roots.

Biological interactions

Mycorrhizal colonisation increases the *Azospirillum chroococcum* population in the rhizosphere and maintains it at a high level for a longer period of time.

The beneficial effect of free-living nitrogen fixing organisms on plant growth is mainly due to hormone production in addition to nitrogen fixation. PSB survives for a longer period in the rhizosphere of mycorrhizal roots.

The PSB renders more phosphorus soluble, while VAM enhances its uptake.

SERI SUVARNA

Sequence /Steps of activities involved in in seri suvarna (trenching and Mulching)

1. Bottom prune the mulberry of the existing garden
2. Plough the mulberry garden for loosening the soil and to execute operations easily.
3. Identify the slope and put against the slope, either to partition or along the boundaries considering the soil characteristics and rainfall pattern.
4. Open the trenches in alternate rows initially with the size of 2 ft width and 1.5 ft depth.
5. Fill a layer of 4 tons of chopped green biomass, and then added another layer of 5 tons of compost/FYM.
6. Open up the trench in the adjacent row with check ridges at the interval of 10- ft all along the trench. Use the excavated soil to close the already opened Trench.
7. Apply recommended dose of chemical fertilizer N:P:K @50:50:50kg/ha considering soil moisture status and rainfall. Apply 50 percent of the nitrogen in the first instalment and the remaining 50 percent after the first crop along with the identified soil deficient micronutrient /to the sub soil if any.
8. After 1 or 2 crops, or at the end of rainy season, mulch the exposed trench with locally available mulches like green leaves or mulberry twigs to cover the soil moisture by preventing evaporation.
9. Synchronizing the onset of monsoon. grow one or two rows of leguminous crops like cowpea/horse gram etc and plough back to soil as insitu green manure.
10. Intercultural operations like manual weeding, loosening of soil if required can be under taken. Repeat the operations considering the soil fertility status and crop stability as and when in demand.

Lecture-6

Mulberry pests

1. Mulberry leaf roller: *Diaphania pulvurulentalis*

Common pest since 1905 in South India ,causing economic loss. Up to 100 % infestation can occur.

Infestation is observed all round the year, but severe from July to November. Pest infests all commercial mulberry varieties.

Symptoms: young caterpillar within unopened young leaves secrete white, delicate silky filament which bind the leaf blades together.

Larvae feed on soft green tissue on leaf surface.

Single leaf is rolled up and caterpillar is found within.

Grown up caterpillar feed not only on leaves of apical portion but also damage the young shoot.

Pest is susceptible to pebrine disease. The caterpillar with disease contaminates leaf and such leaf fed to silkworm causes outbreak of pebrine in silkworms. Pest causes dual damage.

Management

IPM strategy

Cultural/mechanical measures

- Clip affected apical portions, collect in polythene containers and dip in 0.5% soap solution,
- Collect and burn dry leaves and weeds in garden to destroy pupae
- Promote activity of bird predators- provide water in small containers in garden.

2. Bihar hairy caterpillar: *Spilosoma obliqua* polyphagous

Occur sporadically in sericulture belt of Karnataka

Occur throughout the year, severe August-December-January

Symptoms: nature of damage- young caterpillar is gregarious and feed on green soft tissue of tender leaves leaving behind only veins sclerotization. Grown up leaves feed on entire leaves and defoliate the plants.

Management- IPM strategy

Cultural measures

- Collect and destroy egg masses and gregarious young caterpillar by crushing.
- Use light traps to attract moths, place soap solution below light source

Chemical control

- Spray 0.15% DDVP

Biological control

- Release *Trichogramma chilonis*- egg parasitoid.

3. Cutworm: *Spodoptera litura*

Polyphagous pest, sporadic on mulberry

Symptoms- cutworms attack shoots of young mulberry and cut them which falls off and dries up. Also feed on leaves of mulberry.

Management IPM

- Collect and destroy egg masses
- Use light traps to attract moths place 0.5% soap solution in tray.

Chemical control

- Spray 0.15% DDVP, 20 days after pruning of leaf harvest.
- Dust 5% malathion on base of plant.

Biological control

- Use spodolure a pheromone trap 2 lures/ acre twice at interval of 15 days. Done after pruning and leaf harvest.

4. Tukra- *Maconellicoccus hirsutus*

Tukra is due to infestation of the mealy bug

Infests all varieties of mulberry and serve in irrigated gardens

Observed throughout the year- severe in summer

Symptoms: Malformation of apical shoot, reduction in intermodal distance and crinckling and curling of leaves particularly apical leaves.

Affected leaves become dark green then pale yellow when attack is severe. White mealy substance will be seen on affected portion.

Bugs suck sap, resulting in stunted growth of plant.

Management

Adopt IPM approach

Cultural- mechanical, chemical and biological methods

Cultural

- Clip the affected plant portions. Collect in polythene container and dip in 0.5% soap solution
- Do not grow alternative host plants like cotton, hibiscus, ladies finger, grapes, guava etc. in vicinity of garden.

Chemical control

- Spray 0.15% DDVP waiting period in 10 days before harvest.

Biological control

- Release predatory cocinellid ladybird beetles *Cryptolaemus montrouzeri* @125 adults/ acre

5. Wingless grasshopper- *Neorthacris acuticeps nilgiriensis*

Serious pest in rainfed mulberry plantation of black cotton

Pest occurs throughout the year. Severe during July- August.

Pest is polyphagous attacks other field crops besides mulberry and mulberry leaves. It's a defoliating pest.

Adult is light green- lays eggs in soil

Management : Cultural/ mechanical

- Plough infested garden immediately after monsoon to expose egg masses to sunlight/ predators.
- Maintain field sanitation, keep mulberry garden free from alternative hosts

Chemical control

- Spray 0.076% DDVP on mulberry foliage.

Lecture-7

Mulberry diseases

Fungal Diseases

Leaf spot

Causal organism fungus *Cercospora moricola* belongs to family Moniliaceae order moniliales of class Deutromycetes

Disease symptoms small brownish irregular spots surrounded by chlorotic yellow haloes on both the leaf surfaces. As the disease become severe, the spots enlarge leading to the formation of shot holes. Generally, the disease affects tender leaves and its incidence decrease with the increase in leaf age. *Cecospora moricloa* usually fails to attack mature leaves, as its conidia fail to germinate on them due to extensive symptoms ,the foliage gradually weakens, resulting in defoliation.

Period of occurrence post rainy seasons July to December, Temperature 24-26°C and 70-80% relative humidity is more congenial for the disease

CONTROL

Cultural practices, wider spacing, balanced fertilizer, field sanitation.

Chemical

Fungicides such as Bavistin (carbendazim50%wp .or 05%), Benlate (benomyl150%wp),dithanem-45(Mancozeb 75WP), Baycor (Biteranol).0.2% Bavistin is found to be more effective. 2gm Bavistin in one litre of water. Safety period 3-4 days of spray.

Other leaf spot diseases

Black leaf spot *Colletotrichum gleosporioides*

Grey leaf spot *Pseudocercospora mori*

Powdery mildew

Causative organism : fungus *Phyllactina corylea* belonging to family Erisiphaceae order Erisiphales class Ascomycetes

Period of occurrence December-February, yield loss up to 20%

Symptoms white powdery patches on the lower surface of mulberry leaves the corresponding portions of white powdery patches on the upper surface develops chlorotic lesions on severity of diseases ,white powdery patches turns to brownish black in colour, the leaves become yellow, coarse and less nutritive

Control

Wider spacing 90x90cm or paired row spacing 150 +90 x 90cm.

Chemical

Bavistin (Carbendazim) 50 WP or a copper formulation ,Karathane , Dinocap 40% EC at 0.2% can be sprayed on the lower surface of the leaves immediately after noticing the symptom.

Biological Control : yellow lady bird beetle ,*Illias cincta* Fab. and *I.indica* Timb

Varietal resistance: Varieties Kalikuttai, Mandalaya ,china white and MR2 are resistant and need to be used.

Leaf rust

Two types of rusts namely leaf rust and red rust exist.

Leaf rust is common in India

Caused by Fungi *Peridispora mori* of Family Uredinaceae, Class Basidiomycetes

Period of occurrence is November –December with Temp.22-26 ° C and Humidity 70%.

Symptoms

Disease appears as numerous pin sized circular to oval, brownish to black eruptive lesions on the lower surface of mulberry leaves and small brownish spots on the upper surface ,leading to yellowing, drying and premature leaf fall.

CONTROL

Cultural methods:

Wider spacing, inter cropping of soyabean, green gram, forage crops such as ragi and maize

Chemical method : spraying of Kavach (chlorathnolil 75% WP

Varietal resistance :

Almora local is moderately resistant to the disease.

Root rot

The disease is soil borne in nature and spreads fast primarily through contaminated soil, farm implements and irrigation water logging conditions for a longer period and poor health of soil further enhances the disease severity. The secondary source of infestation is plantation of diseased saplings.

Various type of root rot diseases, affect mulberry plants. The root rot caused by *Fusarium solani* Mart Sacc and F.O, particularly in the traditional sericultural belt of southern peninsular India where as violet root rot *Helicobasidium mompa* Tanaka and white root rot *Rosellinia necatrix* Berl.ex prill occur in other sericultural countries.

Symptoms

Decaying of root and decayed root become black due to black powdery mass below the bark. The leaves show withering symptoms when most of the roots are decayed. The affected plants can be easily up rooted. The bark is peeled off easily. The severely affected plants loose the hold in the soil and can be easily up rooted without much force.

Control

Cultural method:

The land should be ploughed and the soil is exposed to sun light during summer months to kill the pathogens in soil. Dead plants should be up rooted and burnt immediately. The up rooted area should be given heat treatment by burning dry leaves and grass over it. Saplings should be raised in plots free from the diseases and sufficient quantity of organic matter should be added.

Chemical method:

As soon as the symptoms noticed apply Dithane M45 10g/pit and after 10-15days apply Raksha and FYM is applied to root zone, after removing the soil to a depth of 15cm followed by immediate irrigation.

For replantation

After digging out the entire mass of diseased roots Dithane M45 is applied to the affected area 10gm per pit and healthy saplings pre treated by dipping their

root system in 0.15 dithane m 45 or Bavistin solution 0.1 gm Bavistin in 1 litre of water. solution for half an hour .After 15-20days dithane m45 application Raksha FYM mixture is applied at 500g/plant .Three more doses of raksha-fym mixture are applied at an interval of 3 months each.

Biological control:

Trichoderma harzianum Rifai isolated from mulberry rhizosphere has been found most potential against the pathogen causing Fusarium root rot disease. A biofungicide, “Nursery guard” that is developed at CSR&TI Mysore .

Stem canker

Is one of the most serious problem caused by Deuteromyceteous fungus, *Botryodiplodia theobroma* .The fungus affects mulberry plantation both at nursery stage as well as established plants. However the damage is more serious at nursery stage.greenish black lesions /eruptions on the stem cuttings. The group of fruiting bodies develop at the affected areas ,which later appear as dark carbonaceous eruption that discharge the black masses of fungal spores The bark becomes dead and decayed resulting in failure of stem cuttings to sprout.

2. BACTERIAL DISEASES:

a. Leaf blight, *Pseudomonas mori*: Young leaves are wrinkled, distorted and curled. Older leaves have water soaked irregular spot on the ventral surface. Management is possible by burning diseased parts.

b. Rot disease: *Bacterium moricolum*: Rooting of leaves and stem is typical symptom. Burning of diseased plants is effective in the management.

3. VIRAL DISEASE:

a. Leaf mosaic: Wrinkling of leaves and shortening of shoot tips are evident.

Management: Eradicating insect vectors using pesticides and removal / burning of diseased plants.

4. MYCOPLASMA DISEASE:

Dwarf disease: Stunted appearance of plants as short internodes are formed. Leaves are very small and arranged irregularly.

Management: Same as that of viral diseases.

5. NEMATODE DISEASE:

The root knot nematode, *Meloidogyne incognita* is a severe problem in sandy soils of irrigated mulberry gardens. Plants have stunted growth as knots develop.

Management: Pulling and destroying the affected plants.

III. DEFICIENCY SYMPTOMS

Element	Symptom	Management
Nitrogen	Plants are weak and grow slowly. Leaves show yellowing, stem is light green and slender, the root system is poorly developed.	Application of Urea, ammonium nitrate or CAN
Potassium	Leaves becoming coarse having rusty brown patches, stem is slender and marginal scorching of leaves is evident.	Application of potash fertilizers.
Phosphorus	Older leaves show inter-venal chlorosis and defoliation occurs.	Application of phosphorous fertilizers or balanced NPK.

Lecture-8

MECHANISATION IN SILKWORM REARING

Required to improve productivity in sericulture and make it highly profitable as any other crop (cash crop).

Working efficiency of facilities must be improved by utilization of machinery, large scale mechanization in sericultural farming was introduced in JAPAN in 1960 and sericulture progressed well.

Silkworm rearing was greatly improved and labour requirement was reduced with significant increase in cocoon yield by 3 times.

Major areas of mechanization were in mulberry cultivation / farming otherwise called moriculture, harvesting of leaves/ shoot, silkworm rearing, mounting of matured larvae, cocoon harvesting and deflossing.

MACHINES USED WERE:

- Mulberry shoot harvester
- Mulberry leaf chopping machine
- Automatic young age rearing machine
- Automatic late age rearing machine

- Jobrai machiene for separating matured larvae
- Cocoon harvester

When a sericulturally advanced country made gigantic strides in cocoon production, making it the world's leader in mulberry cocoon (***Bombyx mori***) production, India can also make a leap by mechanization.

Currently in India, machienes are used to plough the land, practicing intercultural operations when paired row system of mulberry planting is undertaken, large scale farmers venture in using leaf chopping machienes for chawki rearing, shoot harvestors are in the offing, rotary mountages are utilized for bivoltine silkworm breeds/hybrids. There is immense scope to further mechanise sericulture at the level of silkworm rearer. After cocoon harvest, silk reeling is highly mechanised as Silk reeling is an industry in itself, with all importance given to silk quality and the boost given to powerlooms.

Lecture-9

MORPHOLOGY AND ANATOMY OF MULBERRY SILKWORM

Silkworms pass through a complete metamorphosis (Holometabola) from egg to adult stage through two intermediate stages namely larva and pupa.

1. Egg: Oval, tiny as big as the head of pin, smooth, yellow, non-hibernating eggs brighter than the hibernating eggs, 1 to 1.3 mm in length, 0.9 to 1.2 mm in width and weigh 0.5 to 0.6 mg. the eggs of European breeds are comparatively larger and heavier. Breeds producing white cocoons lay pale yellow eggs while breeds producing yellow cocoons lay deep yellow eggs. In both cases the Japanese breeds lay slightly darker eggs than Chinese breeds. The hibernating eggs laid by bivoltine and univoltine breeds become dark brown or purple with the deepening of the colour of the **serosal pigments**. The egg is covered by an egg shell called '**chorion**' provided with follicular imprints on surface. At the anterior end there is "micropyle".

2. Larva: Eruciform, body divisible into head, thorax and abdomen. Freshly hatched larva with large, lustrous black head, dark brown body with hairs, attains maturity in about 26-30 days.

Head: Head formed by 6 highly fused embryonic segments: light grayish-brown: the epicranium forms the whole upper region of the head with inverted 'Y' shaped Epicranial sulcus. The important appendages are a pair of 5 segmented antennae and mouth parts. Labrum, labiomaxillary complex, pair of hard mandibles, six pairs of ocelli are present near the antennal base. Mouth parts are adopted for biting and chewing (**mandibulate type**) represented by hard powerful mandibles for cutting or

crushing the food, two maxillae with 3 segmented maxillary palpi. Submentum is divided into 3 sclerites, mentum very large and less chitinised part. Prementum is borne on mentum carrying **spinneret** and 2 segmented labial palp on either side.

Thorax: This consists of 3 segments namely pro, meso and meta thorax each carrying a pair of thoracic legs ventrally. A pair of spiracles is borne on prothorax.

Abdomen: this consists of 11 embryonic segments but 9 segments are clearly visible since last three segments are fused to form composite segment. The 8th segment bears a backwardly projecting mid-dorsal horn like structure called 'caudal horn'. Third to 6th and last abdominal segments possess each a pair of prolegs with crochets. A pair of lunules (crescents) and star spots respectively are present on dorsum of II and V abdominal segments. Male worms can be identified by a milky white spot called 'Herold's gland' present in between 8th and 9th segments ventrally. A pair of milky white spots each on 8th and 9th segments ventrally called 'Ishiwatas' fore and 'hind glands', respectively are present in female.

DIGESTIVE SYSTEM

Well developed in larval stage, rudimentary in adult.

Larval stage is the only feeding stage in the life cycle of *Bombyx mori*.

It's a straight tube from mouth to anus, also called Alimentary canal and consists of three parts namely 1) Foregut or Stomodeum 2) Midgut or Mesenteron 3) Hindgut or procyodeum

Foregut; composed of mouth cavity, pharynx and oesophagus which is narrow anteriorly and widens at posterior end. Cardiac or Stomodeal valve is located at the end of Foregut, which helps in retaining the chewed leaf bits for some time and prevents regurgitation from midgut to foregut.

Midgut: Long, wide cylindrical tube, narrow at posterior end. Digestion and assimilation of food takes place in this region. The inner wall has peritrophic membrane which protects from mechanical damage of food particles (chewed mulberry leaves)

Hindgut: made up of small intestine, colon and rectum. The Pylorus valve is situated near the anterior end of small intestine. It guards and regulates the passage of digested food from midgut to hindgut. Also absorption of moisture from food takes place and elimination of digested food resulting in faecal pellets which are hexagonal and black

Excretory system has 3 pairs of malpighian tubules which arise at junction of small intestine and colon .These tubules are aligned on the digestive system, the ascending tubules run towards anterior side, turn back and open into the rectum. This arrangement is called cryptonephric , conservation of moisture in food takes place and nitrogenous compounds are excreted as uric acid.

SILK GLANDS

These are transformed labial glands ,ectodermal in origin,cylindrical and tubular with characteristically branched nuclei. Silk glands are paired and situated on ventro- lateral sides of digestive system.

Silk glands are divided into three distinct regions- Anterior,middle and posterior. Anterior region is a straight tube opening at the into a duct and posteriorly into the middle region.

The middle region is the largest of the three regions and has three definite flexions or curves. Middle region is again divided three functionally different sections-Anterior, middle and posterior, all of which synthesise “ Sericin”.

The posterior region of silk gland is highly crooked and curved and responsible for synthesis of “Fibroin”.

The wall of silk gland is composed of three layers namely tunica propria, the gland cells and tunica intima’

A pair of small glands known as Fillipi’s or Lyonnet’s glands is situated at the junction of the two anterior regions. A viscous fluid is secreted by these glands, and it is assumed to lubricate passage of silk.

Fibroin and Sericin are the silk proteins in filament produced by ripe worms which spin the cocoons. Middle gland synthesizes Sericin protein and posterior gland synthesizes Fibroin, anterior gland serves as a passage for silk to reach “spinneret” from where silk is thrown out. In the silk glands, silk is synthesized in liquid form, but when thrown out of the body, on contact with air it solidifies. Silk produced by each half of the gland is called **Brin**, which is thrown out as a single thread called **Bave**.

Silk glands are very well developed in the fifth instar and are functional only when silkworm has stopped feeding and ripe or mature.

Lecture-10

HANDLING OF SILKWORM EGGS

Silkworm eggs are to be handled with special care during transportation so that they do not get desiccated.

Usually farmers use cloth bags and paper bags to carry eggs. In these bags, eggs are exposed to adverse climatic conditions, which lead to poor egg hatching and health of larvae. Now transportation bags or egg carrying boxes are available (Developed by KSSR&DI) which maintain temperature and humidity, as they have a lining of foam pad which can be kept moist. Each bag/box can hold 300 Dfls.

Egg transportation bag is made of rigid plastic mesh lined inside with thermacol. These should be used for egg transportation from Grainage to Rearing House.

The eggs are to be properly incubated.

EGG INCUBATION DEVICES:

1. Earthen flower pot method: Pot has 2-3" layer of sand which is kept wet. Pot has holes ½' diameter above sand level. Egg sheets are placed inside and covered with wet clean cloth.
2. Buried earthen pot method: Pot is buried in sand kept wet. Egg sheets are hung inside the pot which is kept wet with clean wet cloth.
3. Double walled chamber method: Meant for large scale incubation (5000 - 6000 Dfls)
It's a chamber made of bricks, sand and cement

Outer wall measures 6 x 4 x 3 and inner wall is 4 x 2 x 3. There is a gap of 3" in between filled with sand which is kept wet. Egg sheets are hung in the chamber..

4. Low cost incubation chamber (LCIC) : Provides adequate temperature and humidity. Eggs either on sheets or loose eggs are incubated with optimum temperature of 25 C and 75 -80 % humidity.

Multivoltine eggs hatch in 10 days , so also acid treated bivoltine eggs.

Incubation is done upto pin head stage/ eye spot stage that is eight days old eggs or blue egg stage (nine day old egg).After incubation Black boxing of eggs is essential.

Light has a profound effect on egg hatch. Preserving the developed eggs in total darkness for a day (at blue egg stage) or two days (at eye spot/ pin head

stage) before hatching is called “**Black boxing**”. This helps in uniform egg hatching on a single day.

During black boxing, those embryos in advanced stage of development stop further development and this facilitates others to catch up with development.

Simple black sheet of paper (thick drawing sheet) or cover which provides total darkness is ideal.

Card board box lined with black cloth can accommodate more layings.

Eggs are grouped (@% - 50 Dfls) in a tissue paper and covered on pin head stage, and transferred to black boxes. Black boxes are placed under required temperature and humidity conditions. The eggs are exposed to light between 6 am- 7 am, next day. Eggs will uniformly hatch on same day.

Postponement of Egg hatch:

Multivoltine eggs (1day old) can be safely preserved at 10 C upto 40 days without much effect on egg hatching..

Bivoltine eggs could be made to hatch between 10 to 365 days adopting different schedules of preservation.

Bivoltine eggs before entering diapause/ hibernation are acid treated (<20 h old) then incubated will hatch in 10 days.

Eggs of bivoltine, pure or hybrid silkworm races can be cold stored for 40 -130 days at low temperature of 5 C

Bivoltine races: NB7, NB 18, KA, NB4 D2, CSR2, CSR4

Bivoltine hybrids: NB7 x NB18, CSR2 x CSR4, CSR18 x CSR 19.

After Black boxing, there is egg hatching and the next operation is “Brushing”

BRUSHING: Transfer of newly hatched larvae (ants) from egg cards with bird feather to wax paper/paraffin paper placed in rearing trays is called brushing.

In wooden Tray (4' x 3') – 50 Dfls can be brushed and reared upto first moult. 25 Dfls can be reared in the same tray upto II moult. Leaf size to be fed is 0.5cm²

Rearing young silkworms' upto III moult is called **chawki rearing**.

Before brushing i.e rearing of silkworms, Rearing house should be disinfected, so also the equipments and appliances.

DISINFECTION

Disinfection of Rearing house is done to get rid of the pathogens which cause diseases.

2 Methods of Disinfection

1. Physical method
2. Chemical method.

Physical method: Cheap and convenient- particularly for equipments

1. Sun drying- Only in summer it is possible in the Tropics.
2. Steaming- not popular
3. Hot air sterilization- most effective –but expensive.

Chemical Method

1. Bleaching powder: used for cleaning, 2-5 % bleaching powder solution is used. It has active chlorine -30%. Action of bleaching powder is optimum under wet conditions. Equipments should be drenched in 2% bleaching powder in 0.3 % slaked lime can be used as spray for room disinfection.
2. Formaldehyde or Formalin: 2 -4 % is used and 0.05 % detergent is added if used as spray for room disinfection. Air tight conditions are essential when formalin is used. Formalin has @ 36% , 800 ml / 10 m² area is recommended. Now formalin is banned for use in Sericulture, for disinfection, Alternatively ,Chlorine di oxide containing products viz. Sanitech, Sanitall plus, Chlorofect, Serichlor 20 are available for room disinfection .These are safe for human beings practicing sericulture, besides non corrosive and environment friendly.

SILKWORM EGG PRODUCTION

Silkworm egg is also called “Seed” . Seed production in Sericulture refers to :

1. Reproductive seed (Pure breed egg)

2. Industrial or commercial seed (Hybrids)

To produce quality hybrid eggs, sound organization of pure breeds is essential. In India, 3 Tier system of seed production at P3 , P2, and P1 Grainages exists.

Rearing of pure breeds is difficult, especially that of bivoltines as they are susceptible to diseases. Pure breeds are reared in separate zones called "Seed Areas", where specialized sericulturists rear silkworms with meticulous care under hygienic conditions to produce seed cocoons.

Seed cocoons are sold at premium price, 1 1/2 - 2 times the price of commercial cocoons.

Seed Areas in Karnataka are categorized into 1. Multivoltine seed area
2. Bivoltine seed area

Multivoltine seed area is also known as Mysore Seed Area, consists of Mysore, Kunigal Taluk and Hebbur Hobli of Tumkur district, Magadi Taluk of Bangalore District.

Silkworm breeds reared are- Pure Mysore, BL 23, BL 24

Bivoltine Seed Area: Parental breeds of Bivoltine hybrids are reared, free from Pebrine disease and synchronization of moth emergence for cross breeding to get Hybrid cocoons. Area includes Anekal, Sarjapur, Attibele in Karnataka.

Breeds reared are- NB4D2, CSR2 , CSR 4 ,CSR5, CSR 16, CSR 18, CSR 19 etc

Both seed Areas produce eggs in 3 Stages or Levels of Seed Production i.e. P 3 , P 2 and P 1 Grainages/Farms which are under control of State Department of Sericulture.

P3 –Grand parent of hybrid is reared and eggs are produced (Breeding Stations) and it is called Basic or Nucleus seed.

P2- Parent of hybrid is reared and eggs are produced (Government Institutes/ State Departments

P 1 – Hybrid egg production , silkworms are reared and hybrid cocoons are produced (commercial cocoons or Industrial cocoons)

GRAINAGE is an establishment where disease free layings (Dfl) or eggs are produced on scientific lines.

Silkworm races reared in Karnataka:

Multivoltine Hybrid: earlier PM xNB4D2 (traditional hybrid) was reared. Now, BL 23 x NB4 D2 is recommended for Rainfed Areas and BL 24x NB4D2 for Irrigated areas.

Popular multivoltine x Bivoltine hybrid is PM x CSR2 also called Kolar Gold, Kolar Chinna and CB gold.

Bivoltine Hybrids – CSR2 x CSR4, CSR2 x CSR 5, CSR 18 x CSR 19, KSO1 x NP2

Hybrid cocoons are sold at Regulated Cocoon markets by open auction following bidding.

Germplasm bank at Hosur has Nucleus Seed- Layings are supplied to P 3 Grainages 9First stage of multiplication

At P3 Farms- rearing is done and P 2 cocoons are obtained through which P2 layings are prepared.

P2 layings are supplied to P 2 Farms for second stage multiplication. Cocoons are sent to P 1 Grainages for third stage of multiplication. P 1 layings are prepared by Government Grainages and some Licenced Seed Preparers (LSP)

Lecture-11

At Grainages, Egg Production techniques or Grainage techniques are followed (Read Laboratory manual for details).

Egg production is done mainly following Egg Card method .Standard egg sheet has 20 layings. Sold as number of layings or Dfls.

The other method is Loose egg production, a new concept, yet to catch up in Karnataka.

Here , eggs are sold by weight.

To get commercial cocoons, meant for silk reeling Hybrid silkworm rearing is practiced.

The rearing house planned for rearing about 300-400 layings should ordinarily have the following accommodation for shelf method of rearing.

1. Chawki rearing room : 10'x 12'
2. Leaf storage room : 10'x 10'
3. Late age worm rearing hall : 20'x 20'

(With verandah of 5' width on all sides)

Silkworms that can be reared with one acre of irrigated mulberry requires the above space for rearing.

I. PLAN FOR MODEL REARING HOUSE:

- It should be a rat proof building with a ledge all-round.
- Building should have verandah all-round with glass windows and doors to provide good ventilation and light.
- The ceiling of rearing house should generally be made of wood or concrete.
- Windows should be placed such that there is provision for free passage of air.
- Orientation of rearing house: The long axis of the building should be aligned in north-south in temperate and subtropical regions and east-west direction in tropical regions.
- Rearing houses should have separate rooms for rearing chawki, storage of mulberry leaf and rearing late age worms.
- Rearing house should be uzi fly proof

II. REARING EQUIPMENTS:

Shelf rearing method requires the following equipments.

1. Rearing stands: These are racks used to accommodate the trays. They may be made of wood or iron. The size depends upon the trays. There should be 10 tiers to accommodate 10 trays per stand.

2. Rearing Trays: The worms are reared in trays. They vary in shape and size. They commonly used rectangular wooden trays measure 3.5' x 2.5'. The diameter of the circular bamboo trays ranges from 3 to 4.5'.

3. Cleaning nets: Cotton or nylon nets are used for cleaning rearing beds. Usually, the following mesh sizes are used for cleaning.

First and second instars	- 2 mm ²
Third instar	- 10 mm ²
Fourth and fifth instars	- 20 mm ²

4. Cocoonage: (Chandrike or mountage): These are meant to enable the ripe worms to spin cocoons. Chandrike is a rectangular bamboo mat on which spiral bamboo tape is fixed which gives support to the ripe worms to spin the cocoons.

5. Dry and wet bulb thermometer: This is used to record the room temperature and humidity during the rearing period. Hygrometer can also be used to record humidity.

6. Charcoal stoves, room heaters/room heating coils: These are used in raising the room temperature whenever the temperature of the rearing room falls below the required level.

7. Room coolers: These are used in cooling the rearing room.

8. Miscellaneous requirement : Chopping board, chopping knife, leaf preserving baskets, leaf preservation chamber, mats, leaf basins, ant wells, bird feather, feeding stands, wax coated paper, foam rubber, wash basin with stand, sand beds, exhaust fans, etc.

III. SHOOT METHOD OF REARING

Instead of rearing stands and trays, shoot rearing racks are required. The larvae after 3rd moult are shifted to shoot rearing shelves for shoot feeding. The ideal size of each shelf of the rack is about 5ft. width and 30ft.length. This can accommodate 20,000 larvae or 50 DFL's up to spinning. Such shelves can be arranged in 2 tiers with an interval of 30 inches or in 3 tiers with an interval of 27 inch distance. The rack is made of wood, bamboo or mild steel.

Advantages of Hybrid silkworm rearing:

1. Larval period is shorter
2. Leaf cocoon ratio is low
3. Reduced larval mortality
4. Cocoon weight/ Shell weight is higher
5. Filament length is more
6. Silk filament is thicker

Cocoons have uniform size and shape

Lecture-12

PESTS OF MULBERRY SILKWORM *BOMBYX MORI* L.

In addition to infection by several pathogens, the silkworm, *Bombyx mori* is also infected by some insect and non-insect pests which contribute for cocoon crop loss.

INDIAN UZI FLY:

Exorista bombycis (Diptera: Tachinidae): It is commonly known as Indian Uzi fly. This is an endoparasite. This fly parasitises silkworms in China, South Korea, Japan, India and Thailand. In India, it also infests other commercial silkworms namely, Tasar, Oak Tasar, Eri and Muga.

In Karnataka, its incidence was observed for the first time during 1982, and has been infesting silkworm and cause loss. The infestation is maximum during rainy season followed by winter and least during summer.

Life Cycle: There are four distinct stages in the life cycle of the fly.

Egg: Eggs are creamy white, 0.45-0.56mm in length and length 0.26-0.32mm in width, oblong in shape and adhered on to the body. Incubation period is 24 to 36 hours.

Maggot: Maggot passes three instars. It is fusiform in shape, some what acute anterior and rounded posteriorly.

I Instar	0.7 to 1.5 mm
II Instar	2.7 to 2.9 mm
III Instar	3.3 to 3.6 mm

Yellowish white in I and II instar and creamy white in III instar. Maggot period is about 6 days.

Pupa: Puparium is oblong, barrel shaped, somewhat oval anteriorly and rounded posteriorly, reddish brown to dark reddish-brown. Body 11 segmented and measures 0.9- 1.2 cm in length and 0.4 – 0.6 cm in width. Pupal period is about 14 – 16 days.

Adult: The fly is blackish-grey in colour. Male is larger than female. There are four longitudinal black lines on the dorsal side of the thorax. Lateral regions of abdomen are covered with bristles, which dense in female than in female. Male can be distinguished from female by the presence of external genitalia covered with

brown hairs on the ventral side of the abdominal tip. The female fly lays around 300 eggs.

Nature of damage: Two to three eggs are laid on the body of silkworm preferably during 4th and 5th instars. The young maggot on hatching from egg bores its way into the body of silkworm through integument as a result of which a black scar is observed in that part of the skin. The maggot feeds on the tissues of the silkworm, especially the fat bodies. The fully grown maggot punctures the body of the larva comes out and pupates in cracks and crevices. The uzi pierced cocoons will be unfit for reeling.

DERMESTID BEETLES (COLEOPTERA : DERMESTIDAE)

The grubs of these beetles feed on stifled cocoons that are stored for long time. Holes are bored and pupae and silk are eaten.

Adults are small beetles with brown elytra and club shaped antennae. They lay eggs on stored or stifled cocoons. The larvae are small, fusiform. The pupae are naked. The larvae and adults feed on freshly spun, stored or stifled cocoons, cut them and make them unreelable.

ANTS: *Camponotus compressus*, *Tapinoma* sp. (Hymenoptera : Formicidae) : Ants pose serious problem to silkworm in poorly maintained rearing houses. They attack the silkworms in rearing trays, spinning worms on moutage and kill them by way of feeding. They pose problem in grainage.

EARWIG, *Labia arachidis* (Dermaptera : Labiidae): It is one of the grainage pests living in crevices and rim of trays. The adult earwig is dark brown and smooth measuring 1.3 cm in length and 0.3 cm in width. The adult earwig holds the abdomen of silkmths with the help of mandibles and pinch with forceps like cerci. As a result black scar develops on the moth. The affected moths die.

RATS: House rat, *Rattus rattus*; House mouse, *Mus musculus*

They are considered as potential pests in grainage, rearing room and filature. Rats have special attraction for silkworm, pupae which form highly palatable and proteinaceous food. Rats feed on grown up worms and spinning worms on moutages (leaving aside silk glands). In addition to these, squirrels, birds and lizards also cause considerable loss to silkworms.

Lecture-13

SILKWORM DISEASES

PEBRINE

Disease is caused by Protozoa, *Nosema bombycis*. Spore of the pathogen, causes disease.

Protozoa has 2 stages in its life cycle, Spore stage and vegetative stage.

Spore is oval, 3-4 microns. Spore consists of (1) Spore membrane enclosing the sporoplasm (2) sporoplasm in form of girdle (3) Anterior and Posterior vacuole (4) Two nuclei in the sporoplasm (5) Polar capsule (6) Polar filament

Pebrine disease is not seasonal, occurs any time of the year. In early stage of infection silkworm appears normal, microscopic examination of the gut/excreta shows presence of spores which are oval, bluish, shiny and exhibit Brownian movement. Later stage of infection results in loss of appetite, retarded growth irregular size worms, many shrink and become flaccid. Pepper like spots appear on larval body.

Source of infection: Egg surface, diseased worms, faecal matter, alternate hosts, contaminated rearing house and appliances and also mulberry leaves.

Disease has trans ovarian transmission, gets transmitted from one generation to another.

Eggs when laid by pebrinised moth are piled up, laid one on top of the other, moths have pepper like spots on body and wings are curled up, relatively smaller in size.

FUNGAL DISEASES

Prevalent during winter and rainy seasons. Two major fungal silkworm diseases are Muscardine and Aspergillosis. White muscardine is caused by *Beauveria bassiana*, occurs in late age silkworms. Aspergillosis is seen in early instars (chawki). The causal organisms are conidia of *Aspergillus flavus*, *A. tamarii*, *A. oryzae*.

Symptoms; Larvae lose appetite, become inactive and on death gradually harden and finally get mummified. The fungus grows within larval body as a parasite, drawing all nutrition, outgrows the larvae, develops fruiting body and produce conidia on the surface after death of silkworm. Conidia colour varies with causal organism. On death, larva acquires colour of causal organism.

White Muscardine is most common among muscardines. Green muscardine is caused by ***Metarrhizium anisopliae***, yellow muscardine by *Paecilomyces farinosus*, Red muscardine by *Sporosporella uvella*.

Aspergillosis conidia are brown or yellow and seen mostly in Chawki worms.

Pre disposing factors for muscardine are low temperature and high humidity, for Aspergillosis , high temperature and high humidity.

Transmission: conidia are dispersed by wind or contact and germinate on larval skin. Alternate host and contaminated rearing house and appliances spread the disease.

Lecture-14

REELING TECHNOLOGY

Art of reeling originated in China.

Reeling is defined as the process of unwinding the silk filament from a required number of cocoons so as to form a single composite thread, after stifling the cocoons.

Three reeling technologies: 1. Charakha 2. Cottage basin or Domestic basin
3. Multi end reeling- Filature

Upon purchase of reelable cocoons by the reeler, following steps are followed:

1. Sorting of cocoons 2. Stifling 3. Drying/preservation 4. Cooking 5. Reeling
6. Silk testing 7. Sale of raw silk or Gredge.

STIFLING: Is defined as the process of subjecting green cocoons (= live cocoons) to hot air/steam in order to kill the pupae to avoid moth emergence .

Different systems of Stifling are 1. Direct (i.e. Sun drying) 2. Indirect

Sun drying: killing and drying of pupa by exposing to scorching hot Sun .Its a simple method suited for small scale handling cocoons, where alternative method is not available. Cocoons are spread out on a mat for sun drying.

Indirect Method:

1. Steam stifling: Killing the pupa in cocoon by exposing to hot(wet) Steam, >100 C.

a) Basket Steaming: In small establishments, 10-15 Kgs of cocoons are placed in bamboo baskets tied with thick wet cloth on the top.

b) Barrel steaming: Barrel is fixed over an oven, 15-20 Kgs of cocoons are stifled.

c) Chamber Steaming: Large scale stifling in huge chambers provided with perforated pipes for steam to pass to stifle cocoons.(Mechanized method).

2. Hot Air dryer- Machines of 2 types a) Shelf carrier type b) Band Type this has Air heating and Hot air circulation ranging 1.0 to 1.5mts/sec

Yamato Dryer ; Batch Type drier and Ushnakoti (without electric power)

Advantage is that pupa is stifled and also dried in the cocoon so it can be stored/ preserved upto reeling.

With steam stifling- pupa has to be subjected to drying if stored/preserved. Prolonged exposure to steam denatures silk proteins(which is undesirable)

Deflossing means removal of floss (outer most layer of cocoon)

Riddling means separation of cocoons based on size(= small, medium & large), its mechanized.

COOKING OF COCOONS

It is done to soften the sericin protein in silk filament.

It means treating soluble protein (Sericin) which binds the filaments in the shell by hot water/Steam to swell and soften the shell so that a small portion of the cocoon filament may be wound on the reel without breaking or getting entangled.

2 Systems exist 1. Floating- open pan type which is traditional

2. Sunken- closed pan type – Scientific – complete saturation of cocoons- better quality silk is obtained.

3 Stages/steps while cooking cocoons

1. Pre treatment: giving water to cocoon shell evenly. Involves soaking-steaming- permeation
2. Steam cooking- involves swelling of cocoon- replacement of air with steam.
3. Post treatment- adjustment- post permeation to prevent cocoon from collapsing

Cooking Methods:

1. **Earthen pots**- cooking floating cocoons

It is disadvantageous because 1. Cocoon cooking is uneven
2. Frequent changing of water is necessary as it becomes dirty 3.
High consumption of fuel is required 4. only small quantity of cocoons can be cooked at a time.

2. **Three pan type**

Three large sized pans are fitted on a table and the first one has water maintained at 90-95 C; second pan has water maintained at 60 -65 C and the third one maintains 90 -95 C. Hot water permeates the cocoons . having passed the cocoons through these three pans, the cocoons are shifted to a cocoon carrier basin which has water maintained at 40 -45 C (this is also called Receiving trough).

After having cooked cocoons, in order to know cocoon denier single cocoon reeling is done. Three Raw silk Denier categories exist and number of ends of cocoon filaments to be united to form a composite thread in Reeling machine end are calculated by Raw silk denier divided by single cocoon denier , this gives the number of filaments from cocoons to be united to obtain the necessary strength for use in reeling machinery.

First silk is collected on a small reel, then re-reeling is done to collect silk on larger reel called standard reel. Silk from this is called Hank ,skeins are made(Indian skein weighs 70 g). Skeins are bundled to form Books using book making machine. Several books are bundled to form Bale. The smallest unit is SKEIN and BALE is the unit for commercial transaction. At **Silk exchange** transaction of silk is performed.

Lecture-15

CHARACTERISTICS OF COCOON

1. Cocoon shape: important characters for differentiating the races/breeds. Different breeds have different shapes round oval, oblong, pointed end (spindle), peanut shape etc.(narrow waist) cocoon shape of Chinese breed is oval/round, Japanese is peanut European is oval.

2.cocoon size: Big, small

Chinese-generally small Japanese big European- large. Size of cocoon shape is expressed as vertical width and horizontal width and unit of measurement is 'mm'.Size and shape of cocoon is decided by silkworm variety

Voltinism- Univoltine is large, Bivoltine is medium, Multivoltine is small.

Variety- Pure breed is small, Hybrid is large.

In round and spherical cocoons shell is comparatively even unwinding thread is easy.

3. cocoon colour (shade)

Cocoon colour includes the colour and its luster. Univesally 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.

Various colours of cocoons have its origin in mulberry leaves which have pigments.

Cocoon luster:

Colour is linked with degree of permability of cocoon shell structure to light and light's reflection capacity.Thick shell cocoon less lustrous (light rays cannot penetrate easily). Thin shell cocoons-good luster.Under optimum temp/ RH during spinning luster is better.

4. cocoon Wrinkle- cocoon shell has a granular surface wrinkled with convolutions and it is called cocoon wrinkles. Cocoon outer/inner shell drying of filament is natural process outer dries first wrinkles of outer one clear and reduced towards inside. At time of spinning movement of head (vibrations)

decides the size of wrinkles 'S' or ∞ type arrangement. Size of wrinkle are uniform, reelability is good if irregular- poor reelability coarse wrinkles, fine wrinkles. Chinese variety- wrinkles are coarse but thinly spread – 'S' type Japanese variety - ∞ type criss cross of filament are more wrinkles are fine and dense. European variety wrinkles feature in between Chinese/ Japanese. Force of contractions of silk proteins decide size (Coarse fine).

5. cocoon shell thickness and Elasticity (Tightness)

Thickness of shell is measured using micrometer unit 0.36-0.8 mm. elasticity is linked to silkworm variety shell thickness, silk filament thickness etc. Chinese and European variety elasticity level is higher.

6. Air and water and permeability of cocoon shell

Aeration –cocoon shell is formed by the overlapping of silk filament criss crosses. Inside shell there are minute air pores, size of air pore decides the aeration. Good aeration- thin shell large size cocoon

Water permeability

Cocoon filament is porosity fiber possessing capillary attraction so moisturizing capacity varies wet cocoon shell and dry cocoon shell. This factors decides cocoon cooking easy reelability.

7.Uniformity of cocoon

It indicates the external features of a batch of cocoons Normal good cocoons are suited for reeling unequal size, small with thin shell double cocoons etc are rejected uniform cocoons with defects affect reeling process. Important factors- evaluation of cocoon lot for reeling.

Uniformity of lot should be >85% Good lot

<70% Bad

70- 85% ordinary lot

Technological quality of cocoon

Weight of cocoon filament (Bave) –It indicates the weight of silk filament reeled from unit qty of cocoon- cocoon shell rte (ratio). It is the ratio of cocoon shell weight and entire cocoon weight and expressed as percentage.

Cocoon shell weight is more, cocoon silk weight is also more 0.4- 0.5 g.

Cocoon shell reeling rate (ratio)

$$\text{Cocoon shell reeling \%} = \frac{\text{wt of raw silk (g)}}{\text{Wt of cocoon shell (g)}} \times 100$$

Reeling discount of dry cocoons It indicates the raw material cocoons consumed in reeling 100 kg raw silk and expressed as %.

$$\text{Reeling discount of dry cocoon} = \frac{\text{cocoon wt}}{\text{Raw silk wt}} \times 100$$

Lecture-16

SERI PRODUCTS FOR VALUE ADDITION

Mulberry and silkworms are excellent bioresource for various medicinal and nutraceutical products. In China, Japan and Korea, the mulberry plant, silkworms as well as silk are utilized for preparation of several products, food additives, cosmetics and drugs.

MULBERRY

- 1) Nutraceutical compounds in leaves: Tea made from mulberry leaves is popular in China, Japan and Korea, is beneficial for diabetic and Hypertensive patients. (DNJ, GBBA in leaves reduces glucose level and blood pressure)
- 2) Antioxidants in mulberry fruits: Ripe mulberry fruits are used to make jam, jelly, pickle and wine.
- 3) Mushroom cultivation from mulberry shoots: Waste from silkworm rearing and harvest can be used for biogas production
- 4) Fuel and compost making from mulberry : mulberry waste wood is a good source of cellulose for paper and chipboard industries
- 5) Mulberry shoots can be used as staking material for climbers of vegetable, ornamental or fruit crops.
- 6) Hard wood from mulberry are used for making hockey sticks, cricket bats

SILKWORM LARVA

- 1) Products from silkworm faeces: In China, chlorophyll, phytol, carotene, triacontinol, pectin is extracted and used in food, chemical, pharmaceutical industries.
- 2) Silkworm litter is used as fodder and compost material

PUPA

Major by products is pupa oil which has numerous industrial applications.

In India, pupa is not being utilized properly and is cause of industrial pollution.

Actually, after oil extraction, oil cake can be used as molding material in bakelite industry.

Silkworm pupa can be used as feed for fowl, fish and pig as it is rich in protein.

A fungus *Cordyceps sinensis* having anti tumor and anti ageing properties has been cultured on pupae/moths, by use of gene recombinants.

WASTE SILK

Waste silk which cannot be reeled or Spun is used to make silk film or silk powder used as feed additive or for Cosmetic products.

Sericin is available material for the preparation of skin care items as it can provide excellent protection against UV rays.

SILK MOTHS

Used as feed for livestock Moths are used for preparation of fungal medicine like the pupa

Lecture-17

Cocoon Marketing

In order to protect the rearer as well as the reeler and to overcome the exploitation by middle men, and to rationalize the price structure, the Central Silk Board (CSB) and the state Government have opened regulated cocoon markets and marketing federations in each state. They also have started government owned reeling units which buy all the extra cocoons at floor price so that they do not perish for want of buyers. Besides the state government have set up centralized Marketing federations and also formulated certain guide lines to be followed for cocoon transactions.

RULES AND ACTS

The following are the guide lines framed by state Government

1. The rearer and the buyer must enroll their names as members of the marketing 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. A marketing officer appointed by the government is made responsible for all marketing operations.
5. If there are no bidders, the federation itself buys them at the floor price and sends to the Government –owned reeling units.
6. The federation gets a nominal commission from both buyer and seller.

As soon as the cocoon reach the market, the rearer is issued a slip in which the quantity of his lot ,and address other things are filled.

The method of floor price fixation is evolved by Central sericulture Training and Research Institute (CSTRI).For example if the shell ratio is 22 , then the renditta is $133/22$ or 6.The renditta value is used for fixing the price by dividing the kakame cost by renditta. The kakame speaks about the standard cost of cocoons required to reel one kg of raw silk. If the kakame cost is 900 then the price of the lot will be $900/6=150$.

Ramanagaram, Siddalaghatta ,Kolar and Bangalore are major cocoon markets in Karnataka. India's largest cocoon market is in Ramanagaram, a tiny town in Karnataka.

LECTURE -18

Silk Exchange

Export Import policy

Main items of export of silk industry are

- 1) silk goods : comprising fabrics, ready made garments, furnishings, embroidery threads, carpets etc: Export of these items are allowed without any restriction on export duty at present subject to the general export regulations announced from time to time.
- 2) Silk waste : Partial restriction
 - a) Banned items
 - i) Non mulberry silk wastes
 - ii Mulberry silk wastes
- 3) Other silk items
 - a) Banned item-Hand spun silk yarn
 - b) On merit items -Raw silk
 - Silk yarn including spun silk and Noil yarn
 - Silk worm seed and silkworm cocoons including reeling of cocoons

Import of silk

In 1955 GOI accepted the recommendation of CSB to channelize the import and distribution of imported raw silk through CSB for safe guarding the interest of indigenous sericulture industry.

Procedure for Export

Exporters of silk goods are required to follow a procedure to enable them to get the import entitlements. Exporters should get himself registered with the CSB. Application should be made in the format and there is no registration fee.

Registration

The authority for registration

Export Product

Registration authority

--

1 . Natural Silk fabrics
The Indian silk Export promotional

Council –Bombay

2 .Silk Carpets -
The carpet Export Promotion

Council and the Development

Commissioner (Handi crafts)

Registration with Central Silk Board

CSB is the authority for preshipment inspection of natural silk goods, silk yarn and silk waste under the Import Policy.CSB has also the authority for issuing a “Certificate of handloom production and “Certificate of origin”required under the schemes.

Economics of sericulture

Establishment costs of mulberry garden (1 year)

SI No	particulars	Cost (Rs)
1	Tractor tilling (4 hr) , harrowing (2 hr) @ Rs. 250/hr	1500.00
2	Final land preparation (4 pairs of bullock) @ Rs. 100/pair	400.00
3	Farmyard manure (8 T) @ Rs. 500/T	4000.00
4	Farmyard manure application (8 mandays) @ Rs. 80.00/M.D (Broadcasting)	640.00
5	Planting preparation ; Ridge- Furrow making 30 mandays	2400.00

6	Planting material (4 cart loads) @ Rs. 100/ cartload	400.00
7	Cutting preparation (3 mandays) (8,000 @ 2,500 cuttings/mandays)	240.00
8	Planting (20 mandays)	1600.00
9	Fertilizer @ 20:20:20 kg NPK/ac after 2 months of planting (100 kg Ammonium sulphate; 125 kg single super phosphate and 35 kg Muriate of potash)	1036.00
10	Fertilizer application (2 mandays)	160.00
11	Irrigation (50 mandays)	4000.00
12	Hoeing/weeding 3 times (30 mandays)	1500.0
13	Miscellaneous expenditure	500.00
	Total	18376.30

Maintenance cost of mulberry garden 1 year (for a period of six months)

SI no	Particulars	Cost (Rs.)
1	Inter - cultivation, digging, weeding, ridge-furrow making- 2 times (40 mandays) @ Rs. 80.00/M.D.	3200.00
2	Irrigation (50 mandays)	4000.00
3	Fertilizer @ 20 N kg/ ac/- after harvest of I crop (100 kg Ammonium sulphate)	498.00
4	Fertilizer application(2 mandays)	160.00
5	Leaf harvest (60 mandays)	4800.00
6	Land revenue	100.00
	Total	12758.00

Maintenance cost of mulberry garden II year onwards

SI No.	Particulars	Cost (Rs.)
1	Farmyard manure (8 tones) @ Rs. 500/ton	4000.00
2	Fertilizer cost (140 :56:56 kg NPK/ac/year) @ (700 kg ammonium sulphate ; 350 kg single super phosphate and 100 kg murate of potash)	5001.00
3	Manure and fertilizer application (8+ 12 mandays) @ Rs. 80.00/MD and Rs. 100/- per bullock pair	4200.00
4	Irrigation (80 mandays)	6400.00
5	Inter cultivation 8 days & 2 pairs of bullock 5 times per year @ Rs. 80/MD and Rs. 100/- per bullock pair	4200
6	Leaf harvest (110 MDs @ 250 kg shoot per manday)	8800.00
7	Pruning (10 mandays)	800.00
8	Land revenue	100.00
9	Miscellaneous	1000.00
	Total	31901.50

Unit -100dfls

Investment on buildings and equipments =

Sl no	Rearing building/equipment	No/qnty required	Rate(Rs)	Cost(Rs))	Life span
	Buildings				
1	Chawki rearing	50	150	7500	25

	house (sq. ft)				
2	Late rearing house (sq .ft)	380	150	57,000	25
3	Mounting hall(sq.ft)	300	75	22500	10
	Total			87,000	
	Equipments				
1	Power sprayer	1	18,000	18,000	10
2	Mask	1	2000	2000	5
3	Room heater	2	750	1500	5
4	Humidifier	2	1500	3000	5
5	Burner	2	250	500	2
6	Mountage,Deflossing machine	1	1500	1500	5
7	Coccon harvester	2	250	500	5
8	Deflossing machine	1	2000	2000	10
9	Egg transportation bag	1	150	150	5
	Total			29150	

Equipmrnts vary with capacity(rearing)					
1	Chawki rearing stand	1	500	500	10
2	Wooden	10	150	1500	10

	rearing trays				
3	Feeding stands	1	100	100	5
4	Leaf chopping board	1	250	250	5
5	knives	1	50	50	2
6	Ant wells	14	25	350	5
7	Chawki Bed cleaning nets	10	20	200	5
8	Litter Baskets/Vinyl sheets	1	250	250	2
9	Plastic basins	2	50	100	2
10	Lear collecting basket	2	50	100	2
11	Shoot rearing box(940ftx5ft3 tier)	1	1000	1000	10
12	Nylon Net	1	1500	1500	5
13	Rotary mountage	40	500	20,000	10
14	Plastic incubation frame	2	50	100	5
15	Plastic buckets	2	50	100	2
Total				26100	