Sericulture Practices for the Hilly Areas of South India

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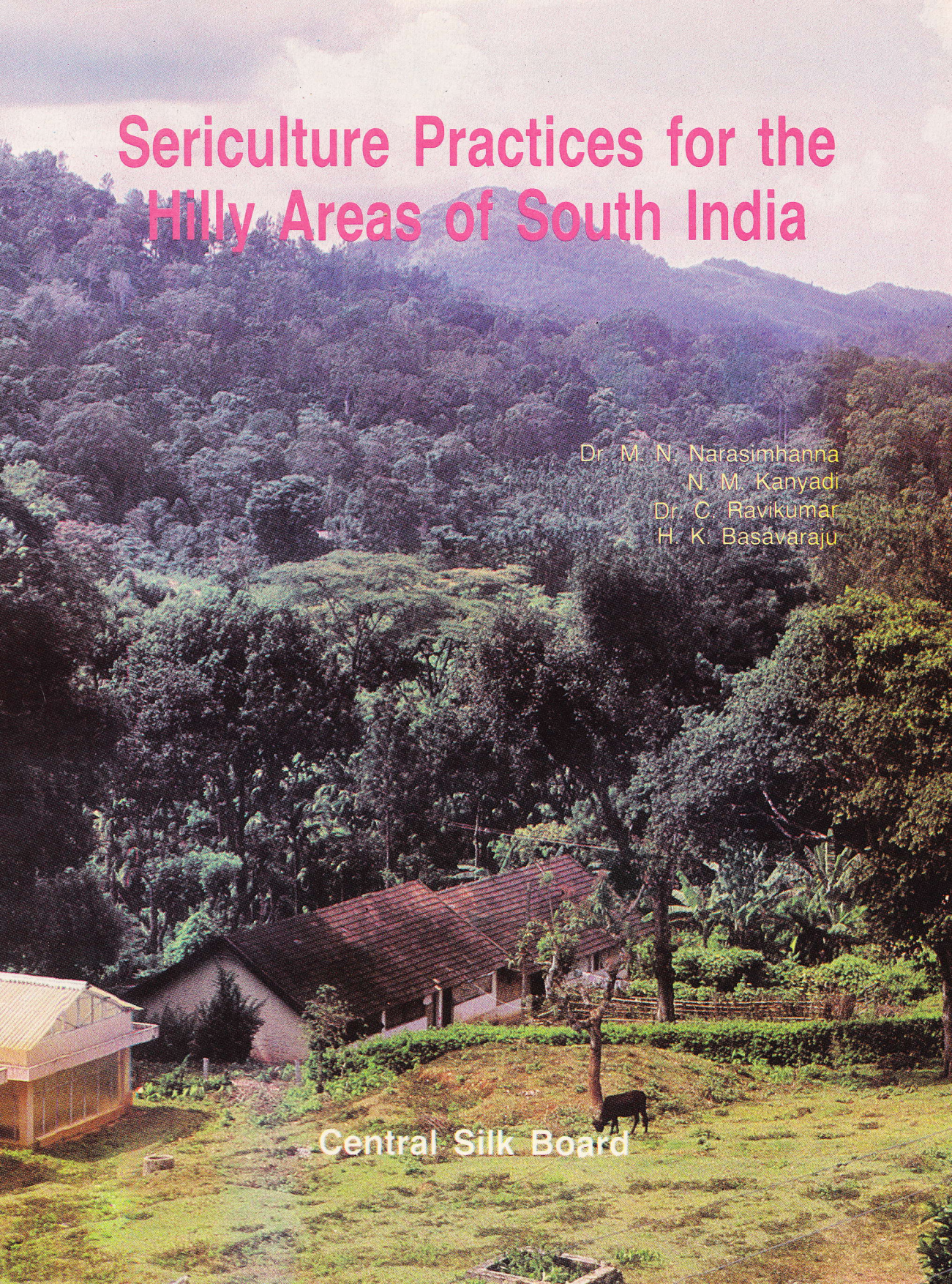

Central Silk Board

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FOREWORD

HITHERTO there has not been much of sericulture development in the hilly areas. Normally in the hilly areas of South India, coffee, tea, cardamom and other plantation crops are grown besides paddy in the valleys. But in other countries like China, the hilly areas with mild climate and high rainfall have sericulture as an important subsidiary activity. One of the break-through which is to happen still in the Indian sericulture is production of bivoltine in a significant way. At present out of the total production of about 8000 tonnes of raw silk, hardly 100 tonnes is bivoltine raw silk though in the cocoon production the percentage will be higher because of bivoltine seed cocoon production.

Bivoltine silkworms require better quality of mulberry leaf and appropriate rearing practices. The hilly areas of South India, especially the entire Western Ghat belt, has rainfall starting from 200" tapering to 25" and in the high lands mulberry grows extremely well. Once the basic nutritious leaf is assured, by following the correct rearing practices and maintaining cleanliness in the rearing room, very high yields of bivoltine cocoons can be obtained. There are farmers in the hilly areas of Hassan in Karnataka, Nilgiris in Tamil Nadu and Idukki in Kerala who have consistently obtained an average yield of 55 kgs. per one hundred silkworm laying which is comparable to the Japanese standards. The cocoons so obtained are also of high quality and in one kilogram there are often only as few as 400 cocoons giving a single cocoon weight of 2.5 gms. which at the rearers level is remarkable.

However, the sericulture practices required in the hilly areas are slightly different from those in the plains. This is because of fairly higher rainfall, milder climate and cold weather during some months. The authors of this brochure have gone into the details and have prepared succinctly useful recommendations. This has been prepared after visiting various farms in the hilly areas. This will be of immense use to the farmers and planters in the hilly areas of South India.

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(V. BALASUBRAMANIAN)
MEMBER-SECRETARY

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SERICULTURE PRACTICES IN THE HILLY AREAS OF SOUTH INDIA

I Introduction

The Hilly areas of South India enjoy salubrious climate for rearing high yielding varieties of silkworms and are ideally suited for rich bivoltine cocoon harvest from which superior quality of silk can be produced. Many of the farmers in Hassan, Chikmagalur, Shimoga, Sirsi, Belgaum in Karnataka, Nilgiri ranges in Tamil Nadu and Idukki in Kerala have successfully taken up sericulture by adopting improved technologies suiting to the eco-climatic conditions. Sericulture is found to be an ideally suited avocation even for those who have taken to plantation crops in these areas. Mulberry cultivation has been taken as 'monocrop' or 'monoculture' in the fallow land of the plantations and is providing an attractive additional income for the plantation owners. This has also helped in engaging and reorienting plantation labour for rich economic returns.

The Hilly areas of south India are generally concentrated on the Western Ghats of Karnataka, Kerala and Nilgiri ranges of Tamil Nadu. The altitude of these areas ranges between 2,500' to 4,000' M.S.L. and the areas enjoy favourable climate for silkworm rearing, except during the heavy rainy season i.e., June-July. The fertile forest, soil, abundant water and good sunshine ensure luxuriant growth of mulberry. These areas generally, experience annual rainfall ranging between 1,000 to 2,500 mm. However, major portion of the rainfall is generally during June to August which provides sufficient water, to the ponds and wells required for good growth of the crops round the year. Even though most of the land owners have taken up plantation crops such as coffee, tea, cardamom, pepper etc., they have also taken to sericulture considering its profitability.

Plantation owners, especially, with small acreage have taken up sericulture as a subsidiary occupation to augment their income. These farmers have huge well-ventilated and isolated houses. Such houses are ideally suited for the good growth of silkworms as they provide proper environment.

Central Silk Board, which has the primary responsibility to propagate, develop and nurture sericulture and silk production in the country, has felt that these, the hilly areas, can be fully exploited for raising rich Bivoltine cocoons and thereby take to production of inter - national grade silk. Technologies adoptable for mulberry cultivation and silkworm rearing in the hilly areas for bivoltine cocoon production are discussed in detail in this brochure.

II. Mulberry Cultivation

The agro-climatic conditions and slightly acidic soils available in the hilly areas are advantageous for good growth of mulberry. The soil in the hilly areas is rich due to forest and has high moisture retaining capacity which are ideal for cultivation of high yielding varieties of mulberry viz., Kanva-2 (M-5) and S-54. These varieties favourably respond to the inputs and cultural practices and thereby yield about 60% more leaf over the local variety. In addition, these varieties produce nutritious leaves which can also retain moisture for a longer period.

a) Establishment of Mulberry Garden

Mulberry can be planted in slopes of hilly areas which are are not prone to water logging. In

slightly slopy lands it is necessary to dig deep trenches around mulberry plantation to provide proper drainage. Wherever mulberry is planted in marginal slope lands, contour bunding is provided to check soil erosion.

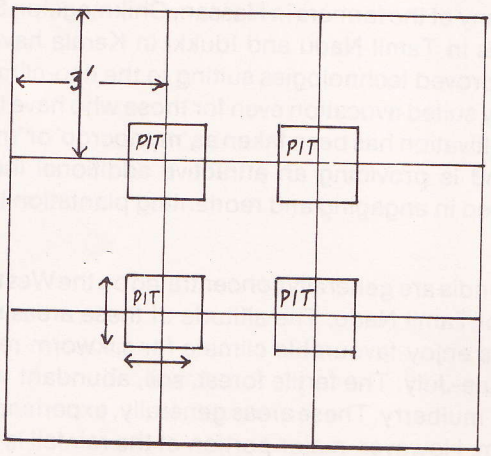


Fig. 1. Pit System (3' × 3')

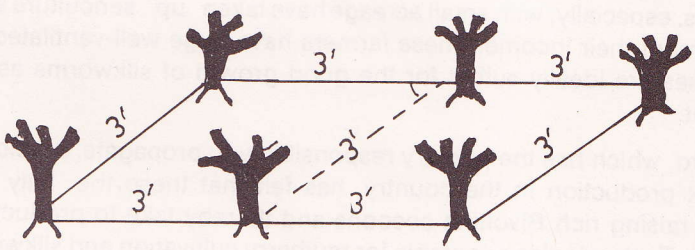
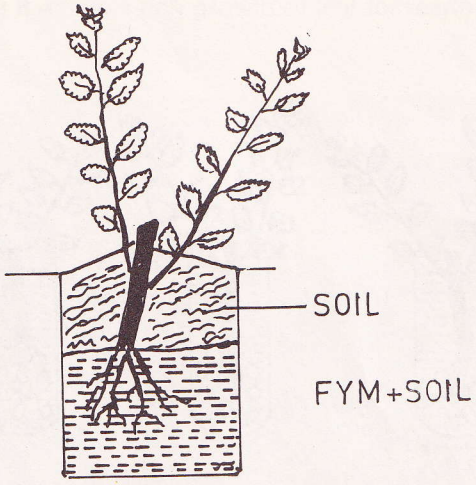


Fig. 2. Pit showing planting method.

June-July months are suited for planting mulberry in hilly areas, as the monsoon rains help for sprouting and rooting of mulberry. Pit system of planting is suited for these areas, having a size 1' X 1' X 1' which are dug at a distance of 3' X 3'. The pits are filled with a mixture of farmyard manure, red earth and soil (fig. 2). Planting material is taken from mulberry shoots, which are of 9 to 12 months old. Shoots having pencil thickness are cut to 9" length and should have about 4-5 live buds for planting. Two to three cuttings are planted at 8" deepth in pits in such a way that one or two buds are exposed outside the pit. This method helps in establishment of roots

deep in the soil as also for easy sprouting. In order to avoid stagnation of water, it is suggested to raise the soil as heap around the cuttings. Whenever there is less rain, the plants should be watered once a week.



It is advantageous to raise mulberry plantations by raising saplings in nurseries separately during the month of March. Nursery beds are prepared with sand and rich farmyard manure. The cuttings which are 9″ in length are planted 4″ to 6″ apart (fig. 3). These nursery beds are

Fig. 3. Nursery Bed.

properly watered at least once in three days. When cuttings are planted in the nursery in March, the saplings attain a height of about 1½ feet by June, which are ideal for transplantation.

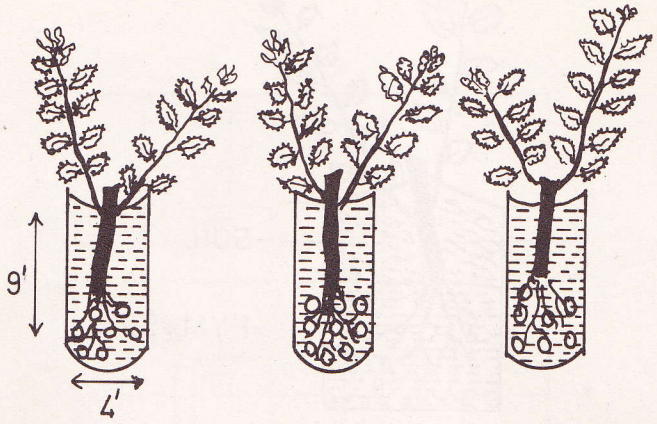


Fig. 4. Polythene bag nursery

Mulberry saplings can also be raised in polythene bags. Polythene bags of 9″ × 4″ size and 150 gauge with holes on the bottom half, are filled with a mixture of farmyard manure, sand and red earth (fig. 4). Mulberry cuttings of 9″ length are planted exposing 2 live buds to light. These polythene saplings are regularly watered. After three months, the saplings can be transplanted by removing the cover. Planting saplings from polythene tubes helps in avoiding injury during transplantation.

After a month of planting, it will be possible to locate pit failures and prompt action should be taken for gap filling with saplings raised in nursery.

Raising 3' × 3' pit system of mulberry plantation helps in better up-take of NPK and other minerals. This also provides copious sunlight for quick and rich growth of mulberry.

b) Cultural Operations

In hill areas, because of continuous rain, weeds grow fast. Even then, it is advisable to take up weeding of mulberry plots after 3 months of planting and to allow good rooting of mulberry plants undisturbed. During the first year it is always advisable to take up inter-cultivation by using manual labour, as the use of bullock power may destroy the establishing plants.

Mulberry requires only one fourth of water required for paddy cultivation. Further, the rich soils of hill areas hold water for long duration. Irrigation for mulberry should be controlled and need not be as frequent as in plains. However, farmer can decide by experience and by looking to the mulberry plants, the need for irrigation. Generally, mulberry needs irrigation once in 10 to 15 days.

After 3 months of plantation, half a bag of urea may be applied as booster dose. This application should be done by preparing 3 holes of 8″ depth and about 6″ away from the plants

(fig. 5). A tea spoon full of urea is applied for each hole and closed immediately. During the first year, 3 split doses of fertiliser are applied at least one month earlier to each leaf harvest. The first dose of fertiliser can be 20 kg. N : 10 kg. P : 10 kg. K ; second dose of 20 kg. N and the third dose of 20 kg. N : 10 kg. P : 10 kg. K per acre. The first dose of complex fertiliser is applied on the 5th month of plantation, so that it ensures rich growth of leaf for rearing silkworms by the sixth month.

Fig. 5. Application of Fertilizer.

The leaf can be harvested for silkworm rearing after six months of planting. Second harvest of leaf can be taken in nine months and 3rd harvest on the 11th or 12th month of planting. During the first year, the total quantity of leaf available is about 4,000 to 5,000 kgs/acre. This will enable rearing of 75 to 100 dfls of bivoltine silkworm for the first crop, 150 to 175 dfls for the second crop and 175 to 200 dfls for the third crop. Leaves for rearing silkworms are to be picked in the cool hours of the day, either 8 a.m. to 9 a.m. or after 4 p.m. in the evening. Leaves are transported in baskets covered with wet gunny cloth (fig. 6).

c) Management of Mulberry Garden from Second Year Onwards

(i) Pruning

Generally, the hilly areas experience heavy rainfall during the months of June-July-August

(ii) Training of Mulberry

During the 3rd year, the plants are pruned 6" above the previous cut so as to allow four to five branches (fig. 8). Such a system will help in training the plant as low cut bushes. This helps in proper aeration and prevent soiling of bottom leaves during rainy season.

Weeding is carried out soonafter the pruning and at least thrice a year. Wherever availability of manual labour is difficult, ploughing by use of bullocks can be adopted. Horsegram may be planted between plants to enrich the soil, and to control weeds. Picking of mulberry leaves for rearing may be carried out even by a stamping of horsegram. After six months when horsegram starts flowering, they may be ploughed back in to the soil. Dhaincha seeds can also be tried as green manure. Such practices, maintain fertility and richness of the soil.

Ten tonnes farmyard manure can be applied per acre per annum in the month of [illegible]-January. Ten cart loads of red earth or tank silt can also be applied alongwith farmyard manure every year.

Fertiliser dosage suggested for mulberry in hilly areas is 100 kg. N : 40 kg. P : 40 kg. K per acre in five split doses corresponding to 5 leaf harvests. Fertilisers are generally applied by making three holes around the plants to a depth of about 8".

During the 2nd year, about 7,000 to 8,000 kgs of leaf can be harvested from one acre of mulberry plantation. This is sufficient to rear about 800 bivoltine dfls in 4-5 crops a year. From 3rd year onwards, 10,000 — 12,000 kgs of leaf can be harvested per acre which is sufficient to rear about 1,000 bivoltine dfls (fig. 9).

Fig. 9. Mulberry Garden.

These are some of the general guidelines suggested, which may be modified to suit a particular ecological conditions of the area. The calender of operations for mulberry cultivation in hilly areas is as under:

Table: Calender of events for Mulberry cultivation in the hilly areas of South India (Second year onwards)

Sl. No.	Operations	Schedules
1.	Annual base pruning (18"-24" low cut)	3/4 week of June (After the commencement of South West monsoon rains)
2.	Weeding, intercultivation, preparation of ridges, furrows and drainage channels	within a week after pruning
3.	Sowing of horsegram seeds as green manure intercrop	1st week of July (within second week of prunning) 3rd week of July.
4.	First dose of complex fertiliser (20 kg of nitrogen, 20 kg of phosphorous, 20 kg of potassium)	(Within 4 weeks of pruning and 3-4 weeks before the next leaf harvest)
5.	First leaf harvest and silkworm rearing	Mid August to 2nd week of September (Brush about 200 dfls)
6.	Cocoon harvest	Mid September
7.	Second dose of fertiliser (20 kg of nitrogen only)	Late September (within 2 weeks after the last leaf harvest)
8.	Second leaf harvest and Silkworm rearing	Mid October to 2nd week of November (brush about 190 dfls)
9.	Cocoon harvest	Mid November
10.	Weeding and mulching of Horsegram plants into the soil	3rd week of November
11.	Sowing of other green manure seeds (Dhaincha)	4th week of November.
12.	Third dose of complex fertiliser (20 kg of nitrogen, 20 kgs of phosphorus, 20 kg of potassium)	4th week of November.
13.	Third leaf harvest and silkworm rearing	Mid December to Mid January (Brush about 180 dfls)
14.	Harvest of cocoons	2nd week of January
15.	Middle pruning (About 9" above the previous annual base pruning)	2nd week of January.
16.	Application of FYM/compost (tonnes/ acre)	3rd week of January (within a week after middle pruning.)
17.	4th dose of fertiliser application (20 kgs of nitrogen only)	1st week of February (After 2nd week of pruning)

18.	4th leaf harvest and silkworm rearing	1st week of March to last week of March (Brush about 220 dfls)
19.	Cocoon harvest	1st week of April
20.	Weeding and mulching of the green manure plants into the soil	2nd week of April
21.	5th dose of fertiliser application (20 kgs of nitrogen only)	2nd week of April
22.	5th leaf harvest and silkworm rearing	1st week of May to IV week of May (Brush about 220 dfls)
23.	Cocoon harvest	1st week of June.

III. Plant Protection Measures for Mulberry

a) Diseases

Mulberry when grown in high humid conditions is prone to mainly two diseases, namely powdery mildew and leaf spot diseases (fig. 10). These are common during and just after rainy seasons in high altitude. When plants are raised at closer distance in the garden these disease attack mulberry severely, making the leaf unsuitable for silkworm rearing. Wider

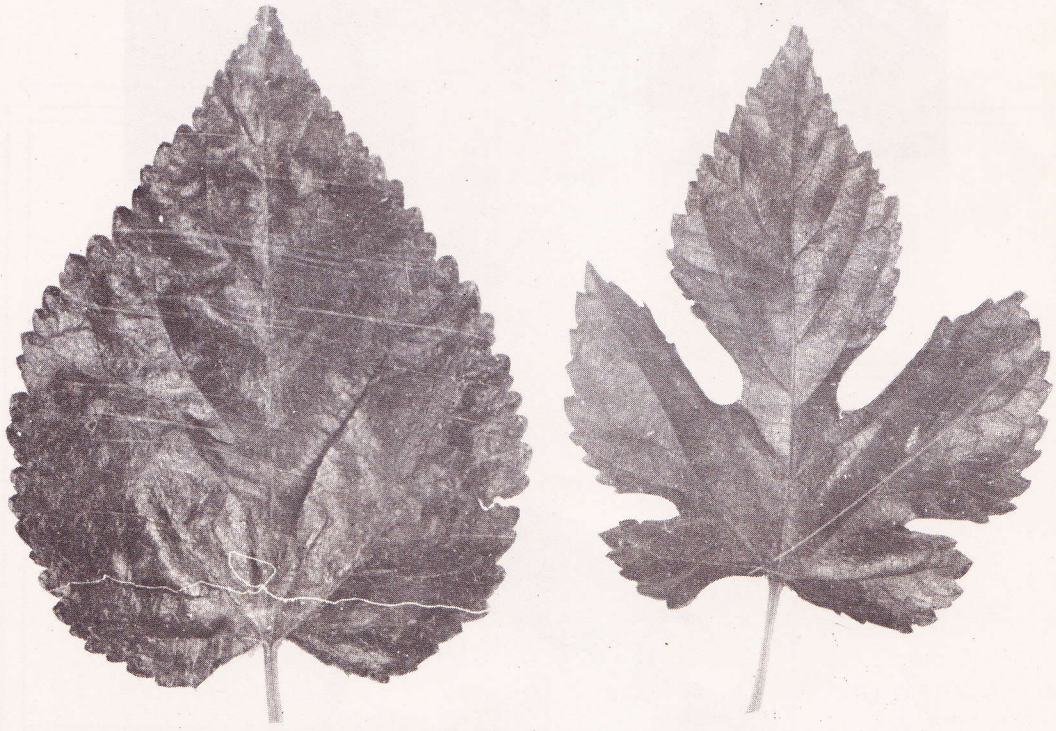


Fig. 10. Powdery Mildew.

spacing helps in better aeration and reduce humidity. Even in such conditions, these two diseases may become rampant. Hence spraying of fungicides, such as Dithane M-45 in 0.2% or Bavistin of 0.1% concentration to the leaves are effective. Leaves may be fed to silkworms after 15 days of spraying without any ill effects. Spraying of these fungicides can be taken as a regular precautionary measures during July-August or whenever the rainfall is heavy and continuous.

Fig. 11. Hairy Caterpillar.

b) Pests of Mulberry

Agro-climatic conditions at high altitudes favour the growth of lepidopterous insects. Generally, mulberry in these regions is attacked by *Diacrisia oblica*, the Bihar hairy cater pillar (fig. 11). The moth lays deep yellow eggs on the lower surface of mulberry leaves. These eggs hatch and the young cater pillars accumulate in groups on the lower surface of the leaf. The first symptom of the attack is, these caterpillars are seen alongwith reticulate leaf as the larvae eat away the chlorophyll when such primary infection is noticed immediately spraying of 0.2% of DDVP or Dimecron 0.2% is suggested.

Generally, grownup larvae of Diacrisia being poly phagus in habit, crawling in swarms to mulberry from neighbouring areas. The worms have black head with brownish body and black hairs. They are gregarious in habit and voracious eaters, so much so that plantation is denuded in a short span of time. 0.2% DDVP or 0.2% Dimecron can be sprayed. DDVP sprayed leaves can be fed to silkworms after 3 to 4 days of spray, while the one sprayed with dimecron can be fed after 15 days of spray.

IV. Silkworm Rearing in the Hilly Areas

The climatic conditions of these areas enjoy high humidity of 60 to 70 percent throughout the year which is ideal for rearing of bivoltine silkworms. This also helps in maintaining the

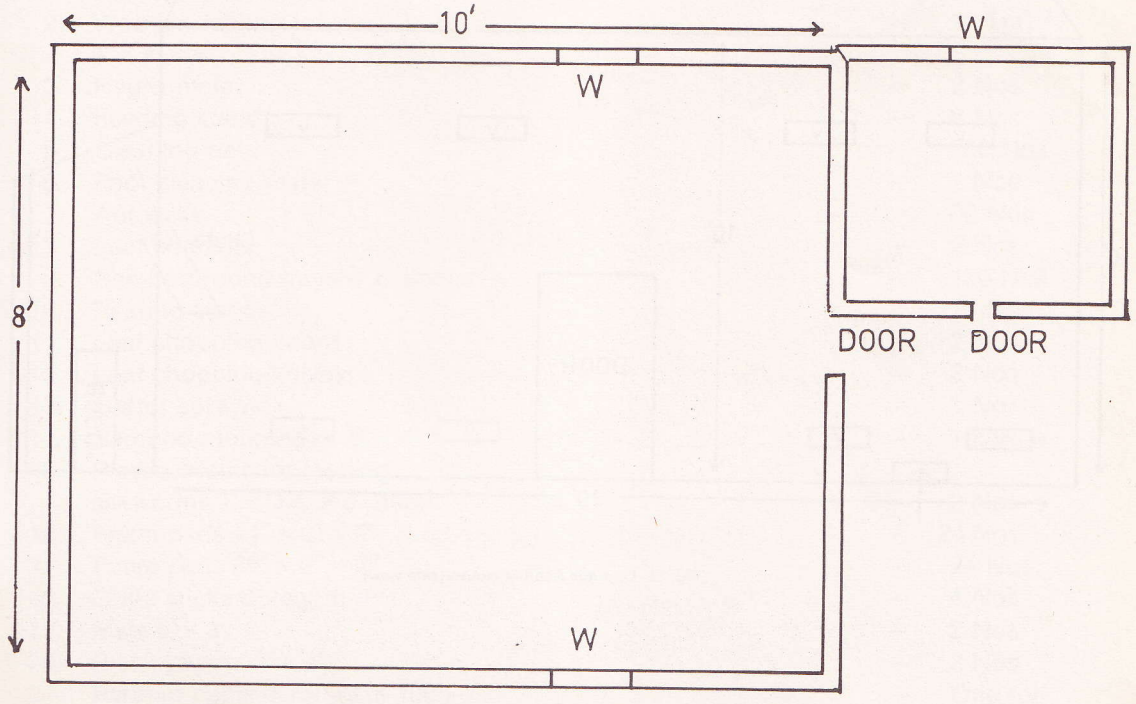


Fig. 12. Ground plan of Chawki Rearing House.

freshness of leaf for longer duration of rearing which enables the farmers to reduce number of feedings to 3 to 4 per day instead of 4 to 5 feedings, generally practiced in plains.

Silkworm rearing technology for hilly areas is discussed as under.

a) Rearing House

In Hilly areas an acre of mulberry yield is sufficient for rearing 200 to 250 dfls at a time. Considering this factor, a small compact Chawki Silkworm Rearing house of 10' × 8' and late age silkworm rearing house of 30' × 16' are suggested (fig. 12).

b) Chawki Rearing House

It is always advisable to select compact rearing house with proper windows and doors for maintaining higher temperature and humidity for young-age silkworm rearing. The Chawki silkworm rearing house should have only one entrance to avoid frequent visit of workers and to maintain hygiene and required temperature and humidity conditions. Two Chawki rearing stands and trays can be arranged on one side during rearing. For easy handling about 10 - 12 rearing trays are arranged on one stand. The other stand can be used for piling up at the time of feeding and during moult.

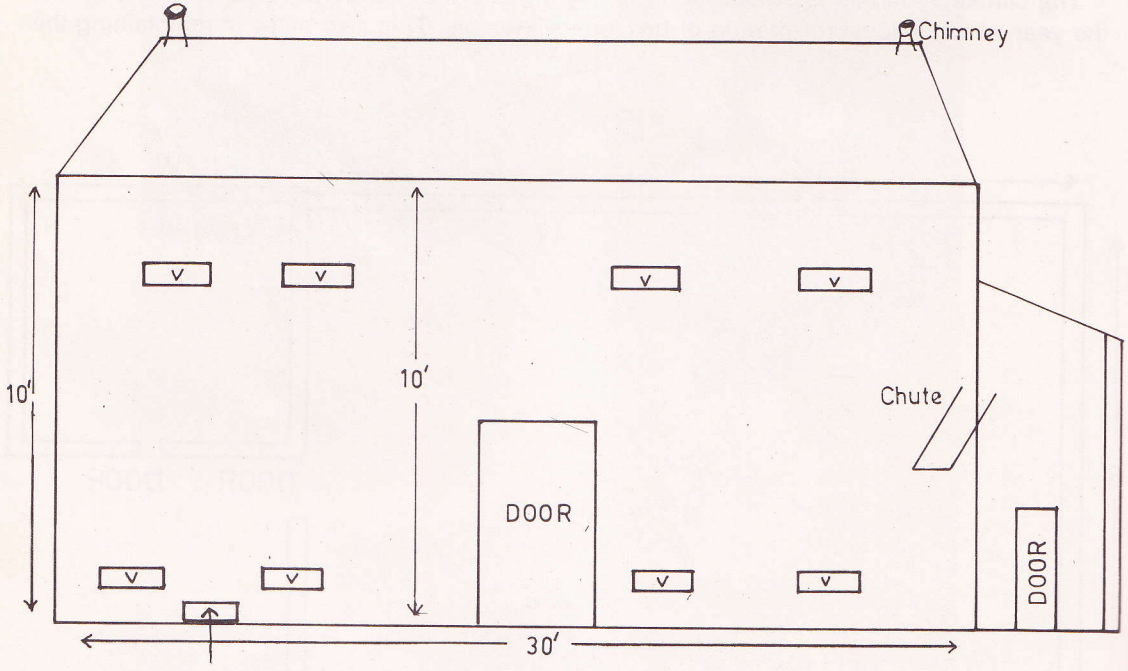


Fig. 13. Late-age Rearing House (side view)

c) Late-age Silkworm Rearing House.

Rearing house should be oriented in east-west direction to avoid heating of rearing rooms due to direct sunlight. Size of the rearing house suggested is 30' length × 16' width × 10' height. It may be provided with roofing of asbestos or R.C.C. (fig. 13). The rearing house should be provided with two rows of ventilators. One row of three to four ventilators can be provided at about one-foot from the ground level and another row at seven foot from ground level. This helps in cross-ventilation and maintaining desired temperature and humidity. The ventilators may be provided with glass doors to close-and-open as required to regulate humidity and temperature during winter and summer months. Hence, it is suggested to construct a small leaf preservation room of 6′ × 6′ adjoining the rearing house. Preservation of leaf covered with a wet gunny cloth in the rearing house will increase humidity. The leaf preservation room may be connected to the rearing house with a chute, so that leaf chopped for silkworm rearing may be transferred easily. Similarly, one more chute can be fixed at floor level to sweep out waste material directly outside. For summer rearing, if the temperature is high, the roof of the rearing house may be covered with straw or coconut mats, which may be kept moist. Such practice reduces temperature in the rearing house. Wherever asbestos or tiled roofing is available, it is suggested to have a ventilator or a chimney at roof level, which enables hot air to escape. It is advisable to provide verandah around the rearing house to allow entry of cool air from outside and also provide space for keeping chandrikes during mounting.

d) Rearing Equipments

Equipments required for rearing of 250 dfls at a time are give below:

1.	Wooden chawki stand	— 2 Nos
2.	Wooden rearing trays 3′ × 4′ × 4″	— 12 Trays
3.	Hygro meter	— 2 Nos
4.	Feeding stand	— 2 Nos
5.	Cleaning nets	— 260 Nos
6.	Foot cleaning mats	— 2 Nos
7.	Ant wells	— 60 Nos
8.	Leaf chamber	— 2 Nos
9.	Bamboo round trays 4′ diameter	— 130 Nos
10.	Rearing stands	— 13 Nos
11.	Leaf chopping board	— 2 Nos
12.	Leaf chopping knives	— 2 Nos
13.	Gator sprayer	— 1 No
14.	Bamboo mountages: 6′ × 4′	— 100 Nos
15.	Plastic basins for feeding silkworms 15″ Dia. × 6″ depth	— 2 Nos
16.	Foam pads 44″ × 2″ × 2″	— 24 Nos
17.	Foam pads 36″ × 2″ × 2″	— 24 Nos
18.	Chop sticks 8″ length	— 4 Nos
19.	Mats 6′ × 3′	— 2 Nos
20.	Black papers 3′ × 4′	— 2 Nos
21.	Paraffin paper-1 roll (3′ × 100′)	— One roll
22.	Feathers	— 6 Nos
23.	Plastic basin stand	— 2 Nos.

24. Formalin mats — 2 Nos
25. Room heaters — 2 Nos

V. Rearing of Chawki Silkworms

Importance of young age silkworm rearing has been fully realised by sericultural technologists both in India and abroad and it is considered to be the foundation for successful crops and harvest of good quality cocoons.

Chawki silkworm rearing is a specialised job. Success of silkworm rearing and the quality of cocoons harvested later, depend on chawki rearing techniques adopted. Proper young age silkworm rearing ensures uniform and quick growth of silkworms. Because of proper care and good growth of worms at early stages, they develop resistance to diseases at later stages. The young age silkworm grow extremely fast. They require nutritious leaf, higher temperature and humiduty for their fast growth. Silkworms grow well at temperature of 25 to 27°C and 85% to 90% of humidity. In hilly areas, the humidity is always high and temperature is low. Hence, temperature for young age silkworms is required to be maintained.

a) Disinfection

Before the receipt of silkworm eggs for rearing, chawki room, rearing equipments etc. must be cleaned with water to remove dirt, remnants of dead larvae etc. Later, they are sprayed with bleaching powder solution. For this purpose, a kilogram of fresh bleaching powder is mixed with 5 buckets of water and sprayed on equipments and walls inside the rearing house. The next day the rearing house should be disinfected with 3% formalin. 3% formalin can be prepared from commercial formaldehyde by following the formula given below:-

$$\frac{\text{Strength of commercial formaldehyde} - \text{Required strength of formalin}}{\text{Required strength of formalin}}$$

= Number of parts of water to be added for one part of commercial formaldehyde.

= that is, $\frac{38 - 3}{3}$ = 11.66 parts of water to be added to one part of commercial formaldehyde to get 3% formalin.

The quantity of formalin required for spraying in the rearing house is calculated as follows:

(a) Length × Breadth (Floor area)
(b) Length × Height of each wall i.e., the area of two walls.
(c) Breadth × Height of each walls × 2. i.e., area of two other walls.
(d) To this, add the area of the surface ceilling or in case of tiled-roof, the surface of the two slopes.
(e) The total of these given areas required for disinfection.

To disinfect 100 sq.ft. of space, about 800 cc of 3% formalin is required. For chawki rearing house of above mentioned dimension, about 4.2 litres of 3% formalin is required. Same quantity is required for disinfecting rearing equipments. Thus, totally, 8.4 litres of 3% formalin solution is required for disinfection of chawki rearing house.

Spraying of formalin should be done between 10 a.m. and 12 noon when the temperature is high. Before spraying, the doors and windows are closed and the crevices, if any, sealed. It is

not advisable to spray formalin during rain and early or later hours of the day. Generally, in hilly areas during rainy and winter seasons when the temperature is low, it is advisable to heat the room before spraying or adopt fumigation technique soon after spraying. Some formalin is allowed to evaporate over an oven with hot cinders and the room is totally closed. Care should be taken to keep that much of cinders to avoid fire hazards. Disinfection of rearing room is always done along with all the rearing appliances. The suitable time for disinfection is on 8th day of egg laying or at the 'eye spot' stage of silkworm egg. The rearing house is opened the next day to allow residual fumes of formalin to escape. Afterwards the room is cleaned, the eggs are brought and kept for brushing.

b) Brushing

The eggs received from the grainages are spread in trays which are provided with paraffin papers for the base. About 6 egg sheets can be arranged in single layers in a tray. Wet foam strips are kept on all the sides and covered with black papers and paraffin papers. In hilly areas, during rainy days when the humidity is higher than 80%, there is no necessity of keeping wet foam pads. On the day of brushing, the paraffin paper and black paper are removed and immediately the egg sheets are distributed to the trays, at the rate of 25 dfls/tray. Later, these eggs are exposed to dim light which enable all the eggs to hatch uniformly. Generally, they are exposed to dim light at 8 a.m. in the morning to facilitate brushing between 9 to 10 a.m.

Tender leaf is sprinkled over the hatched worms on the sheets. Worms are allowed to crawl for about an hour, and are tapped on to the tray. The left over worms, if any, on the sheet, are brushed with a feather.

Now a days, the grainages have started supply of silkworm eggs in loose form. Loose eggs have an advantage over egg sheets in that all unfertilised eggs and dead eggs are removed during the preparation of loose eggs. This will enable only supply of fertilised eggs to the farmers. In such cases where loose egg boxes are supplied, we can brush 50 dfls in one tray and spread the worms in two trays after first moult.

In the blue-egg stage the cloth of the loose egg boxes is torn and the eggs are kept in a tray with paraffin paper at the base. They are covered on all the four sides with foam pads and on the top with black paper and at bottom paraffin paper. On the day of brushing, the black paper and paraffin paper are removed and eggs are exposed to dim light for about 30 minutes. Mosquito curtain cloth of 10" sq is spread over the loose egg boxes and good leaf is sprinkled over the cloth to attract the worms to crawl on to the leaf. Later, worms along with the leaf on the net are shifted and the boxes with empty shells are removed (fig. 14).

c) Environment

The success of young age silkworm rearing depends on 3 major factors viz., (1) proper environment, (2) Proper quality of leaf and; (3) Spacing provided for silkworms, during their growth.

(i) The optimum temperature for first-stage silkworms rearing is 26°C to 28°C and humidity of 85%. Temperature above 30°C is harmful to silkworms. Similarly, temperature below 20°C affects physiology of the worms rendering them weak and susceptible to diseases. The rearing period is prolonged if the temperature is lower than 26°C.

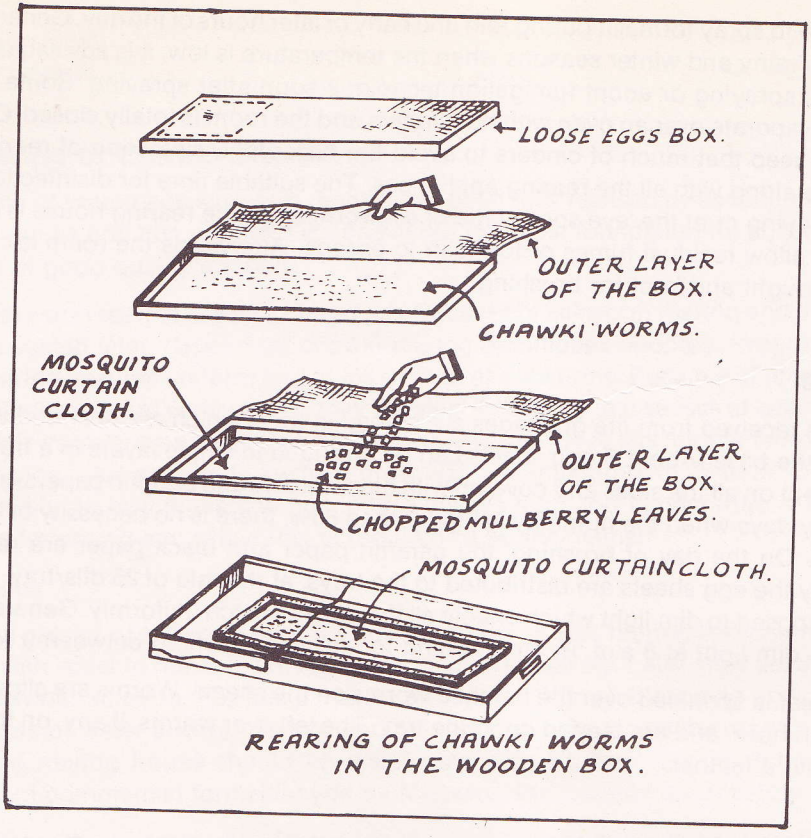


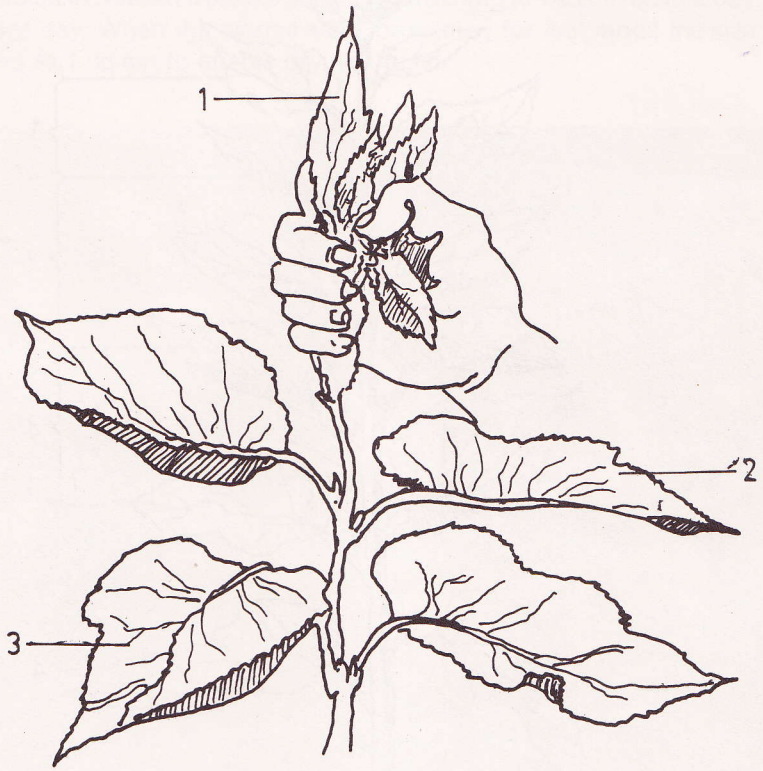
Fig. 14. Loose eggs brushing.

Since the temperature and humidity have direct correlation with growth of silkworm, wide fluctuation of temperature is harmful and should be avoided. When the temperature is lower than the optimum, the ideal way of maintaining temperature is to heat the room through electric heaters. Wherever, this is not available, charcoal stoves partly covered with ash and with hot cinders, which is well burnt outside, are kept in the rearing house. When the temperature raises higher than the optimum, cinders may be covered with ash and can be exposed when the temperature falls.

The optimum humidity required for young age silkworm rearing is 85%. In hilly areas, such humidity is naturally available. When the humidity is low it is advisable to keep wet foam pads in the rearing trays. Generally, wooden trays are suggested for Chawki Silkworm rearing, as the outside environment of the rearing house even if fluctuates do not affect the rearing bed as wood is bad conductor of heat.

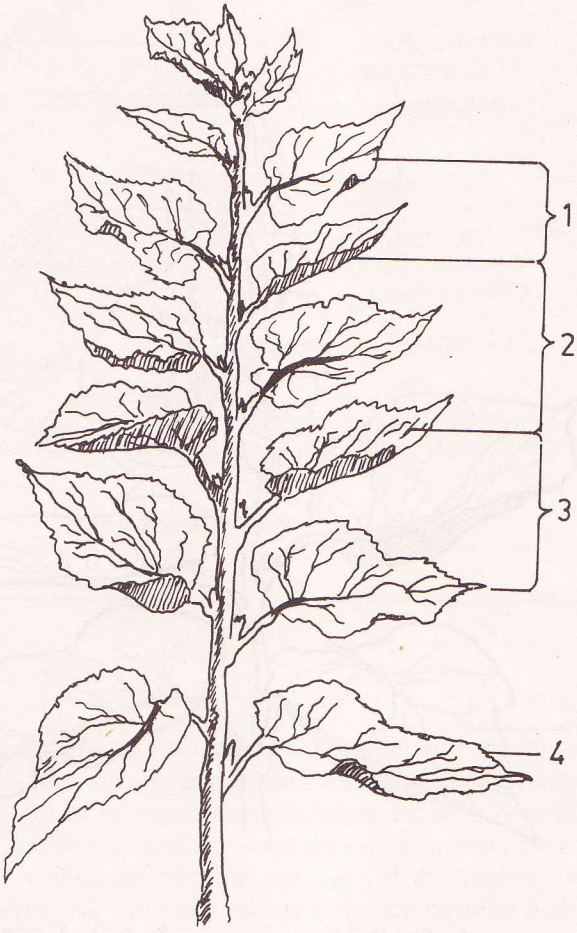
d) Leaf

Most important of all the above factors is the quality of leaf. The largest glossy and succulent leaf from the tip and the four leaves below are ideal leaves for chawki silkworm rearing (fig. 15). The first two leaves are good for rearing first stage worms. The leaves must be succulent, nutritive and healthy for young worms. Poor quality of leaf leads to irregular growth, weak



1. Shoot let. 2. & 3. I age.

Fig. 15. Chawki Leaf.



1. I age. 2. II age. 3. III age. 4. Later ages.

Fig. 15. Selection of Leaves for different ages.

larvae and poor quality of cocoons at later stages. Leaves for chawki silkworm rearing should be collected in the morning at 9 a.m. or in the evening after 4 p.m. Leaves are harvested in baskets covered with wet gunny cloth and transported to the leaf preservation room. They are preserved in leaf chamber covered with wet gunny cloth or in big earthen vessels concealed in wet sand bed (fig. 16). This practice will help in preserving leaves in fresh state and retain its succulency for young silkworms. The leaves are cut to 0.5 sq.cm and fed to silkworms. Four feedings are given in a day at 6 a.m., 11 a.m., 4 p.m. and 9 p.m. When the atmospheric humidity is very high the moisture content in the leaf is also high as in the hilly areas during rainy seasons, we can feed 3 times a day viz., 6 a.m., 1 p.m. and 8 p.m. The size of the leaf for feeding at first stage should be increased from 0.5 sq.cm for brushing to 1 sq.cm on first day, 1.5 sq.cm. on the 2nd and 3rd day. When the worms start for settling for first moult the size of the leaf should be reduced to 1 sq.cm to enable drying of leaf.

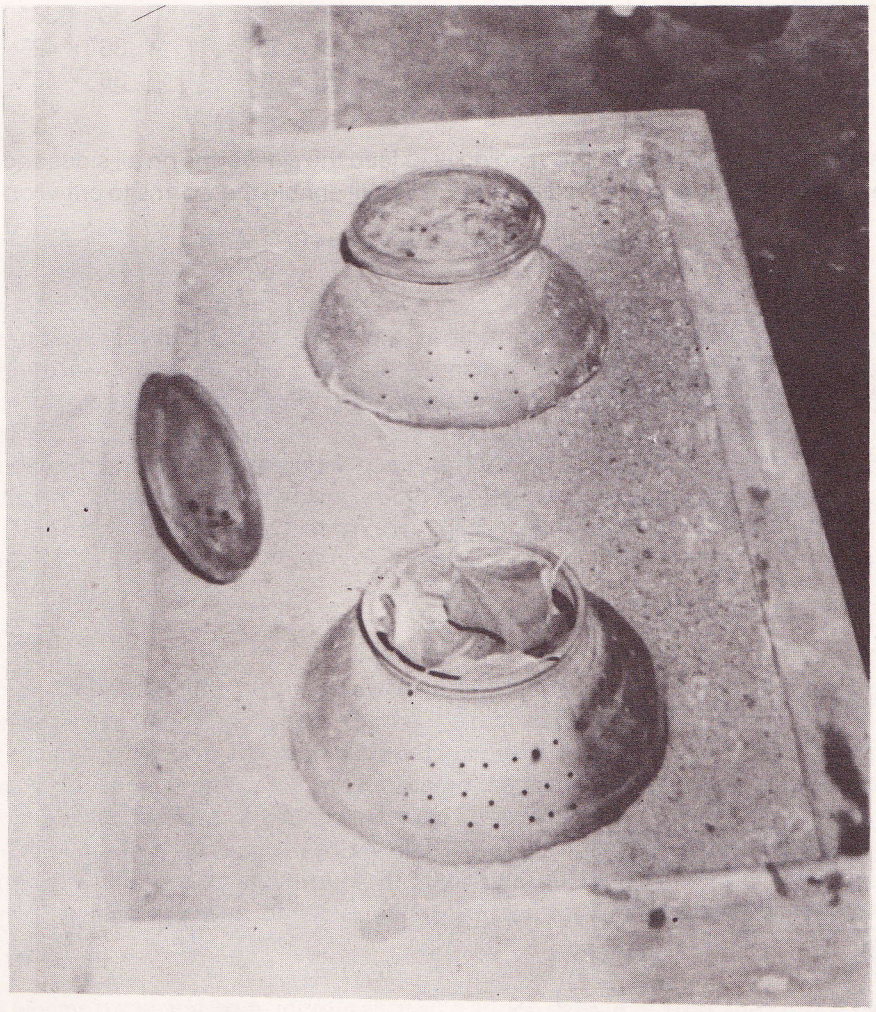


Fig. 16. Chawki Leaf preservation in Earthern Vessels.

e) Spacing

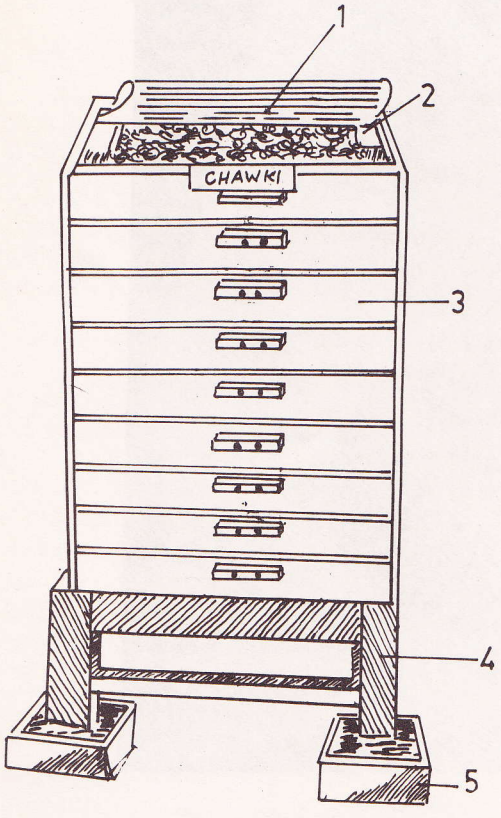
In case of brushing of silkworms from egg sheets about 25 dfls are brushed in a tray. The ideal spacing to be provided is 12″ × 12″ at the time of brushing.

It is always advisable to use chop sticks for providing spacing both at first and second instars, and not to touch the worms, as far as possible, by hand to avoid contamination. The chop sticks can be washed in formalin and dried and kept for re-use everyday.

The optimum spacing to be provided in each tray for worms of 25 dfls of sheet eggs and 50 dfls of loose eggs (one box) is given below:

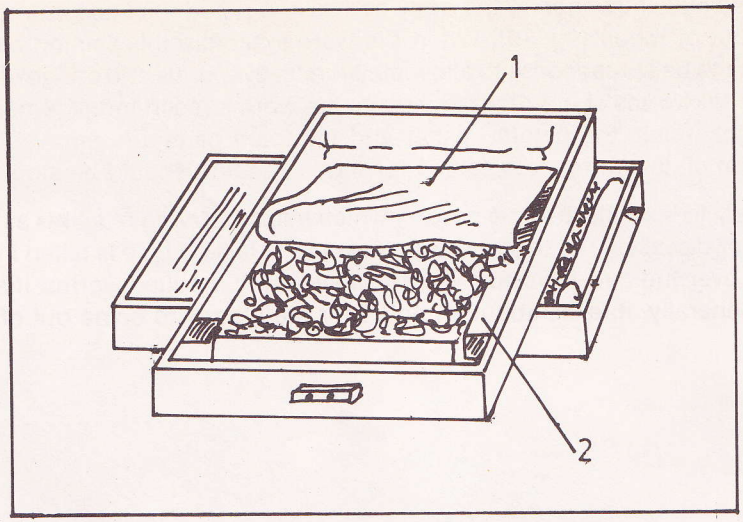
First Instar	**25 dfls**	**50 dfls** (Loose eggs)
1. At the time of brushing	12″ × 12″	24″ × 24″
2. At the end of 24 hours	15″ × 18″	30″ × 36″
3. At the end of 48 hours	18″ × 21″	36″ × 42″
4. At the end of 72 hours	18″ × 30″	36″ × 48″

The ideal method of increasing the spacing is to feed the silkworms on all sides and sprinkle less leaves on the top, during the feeding time. This will enable the worms to crawl on all sides



1. Paraffin Paper. 2. Foam Rubber
3. Rearing Tray (3' x 4') 4. Chawki Stand.
5. Ant well.

Fig. 17. Chawki Rearing (Box rearing).



1. Paraffin Paper. 2. Foam Rubber.
1 and 2 to be removed during drying.

Fig. 18. Criss-Cross arrangement of Trays.

and spread uniformly in the bed. After each feeding, the pads are made wet; kept on all the four sides and covered with paraffin paper. This helps in maintaining optimum humidity for the growth of silkworms and in retaining of the leaves freshness as far as possible. The wooden trays are piled up one over the other on the chawki stand, about 8 to 12 trays, depending on the convenience which can be arranged in one row (fig. 17). Before each feeding, the paraffin and foam pads are removed and trays are kept in criss-cross direction to facilitate free ventilation (fig. 18). This helps to dry the old leaf. This will also enable worms to crawl on to the surface and get ready to receive fresh leaf for the next feeding.

f) Bed Cleaning

Due to periodical feeding, the left-over leaves and faecal matters get accumulated in the bed. Hence, cleaning of bed is necessary. During the first stage, we may give one cleaning after 60 hours of brushing. However, it is advisable not to clean the bed at first stage, but attain the same objective by providing more space and loosening the bed. This is suggested, as the process of cleaning increases the loss of younger worms. For cleaning the bed, cotton nets of mesh size 1.5 sq.cm are spread over the worms and fresh leaves are sprinkled. After about 20 minutes, the nets along with worms are transferred to another tray and waste leaves are thrown out. In case, nets are not available, a layer of leaves along with worms are taken with a feather.

g) Care at Moult

As the worms grow, the body increases in size and to enable growth, the larva throws out its old skin. The process of throwing of old skin and developing new one is called 'moulting'. Generally, the worms before settling for moult acquire shining body surface. The size of the

head becomes small in relation to the body and as compared to eating-worms or the worms which come out of moult (fig. 19). When the worms acquire this shining body surface the rearing bed has to be spread loose to allow moisture to evaporate and driage of leaf. Size of the leaf fed to the silkworms should be reduced as the worms reach moult. When almost all the worms settle for moult, the paraffin paper and the foam pads are removed and the bed is loosened. When all the worms are settled for moult, feeding should be stopped.

It is necessary to sprinkle the lime powder which helps in drying of leaves as well as prevent the incidence of diseases. For this purpose, powdered slacked lime is taken in a muslin cloth and sprinkled over the bed. This also will not allow newly moulted worms, if any, to feed left over leaves. Generally, it takes about 24 hours for the worms to come out of moult.

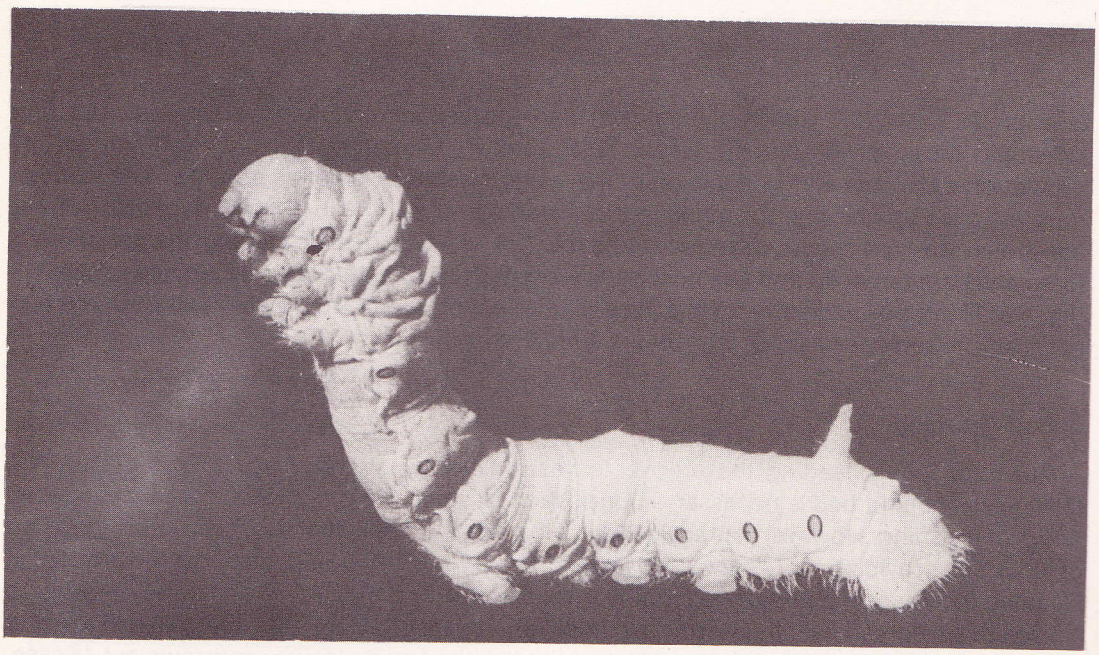


Fig. 19. Larva just out of Moult

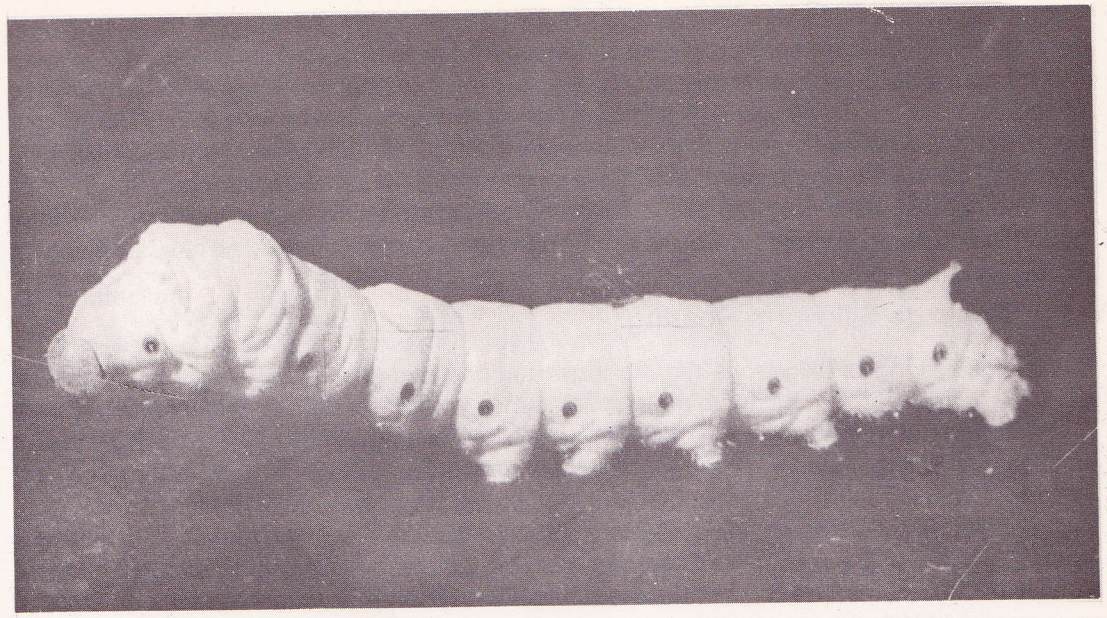


Fig. 19. Larva at Moult

h) Second Stage Silkworm Rearing

Rearing of II stage silkworm is much similar to that of rearing of first stage silkworms. After ensuring all the worms have come out of moult, the net of the size of 1 sq.cm. is spread over the rearing bed and leaves are fed to silkworms. All the worms crawl through the net to eat the fresh leaves. The net along with the leaves and worms transferred to another tray. In case of loose eggs the worms are shifted to 2nd rearing tray. The 3rd, 4th and 5th leaves from the largest glossy leaves are ideally suited for rearing of second stage silkworms. The plucking of leaf and preservation of leaf is followed as in the first stage. The leaf should be cut to 1.5 sq.cm and fed for resuming feeding after first moult. The size of the cut leaves should be increased to 3 sq. cm. as the worms grow to the second moult. The spacing to be provided for second stage in each tray of 25 dfls is given below:

Second Instar:	**Area of Bed**
1. At the time of resuming the feeding after first moult.	18″ × 30″
2. At the end of 24 Hrs.	30″ × 36″
3. At the end of 48 Hrs.	36″ × 48″

The temperature and humidity to be maintained for second-stage silkworms are between 26° C to 28°C and humidity of 85%. The quantum of leaf required for rearing the second-stage of silkworm is estimated to be 6 to 8 Kgs for 100 DFLs. However, this can be changed depending upon the number of eggs per layings. Only one cleaning is suggested after 36 hours of resuming feeding.

As in the case of first-stage, half-an-hour earlier to feeding, the paraffin and foam pads are removed and trays are kept in criss-cross direction. After feeding, the trays are piled up one over the other. Second-stage is the shortest among the other stages of larvae. The worms settle for second moult, in 2½ days after first-moult. During this stage also the worms acquire shining nature and show all the symptoms of moult as in first-stage. When worms settle for 2nd moult, powdered slaked lime is sprinkled over the rearing bed as in first-moult. Generally, the worms take about 24 hours during the second-moult. Soon after resumption of feeding after 2nd moult the bed must be cleaned; worms can be transferred to round trays and can be shifted to late-age rearing house.

VI. Late-age Silkworm Rearing

Late age rearing of silkworms require lower temperatures and humidity as compared to chawki worms. They require much more spacing than young worms. Soon after 3rd moult bed cleaning with net is practiced everyday. (*Fig.21*). Hence, late-age silkworm rearing house must be spacious to accomodate more number of stands and round bamboo trays and provided with cross ventilation to maintain cooler atmosphere. As suggested earlier it must be provided with alround verandah which helps in allowing cool air to enter the rearing house. In hilly areas, where, heavy rains are experienced, the roof must be sufficiently sloppy to check stagnation of water which cools the room lower than required. During summer, wherever the temperature goes beyond 27°C, it is suggested that the rooms are provided with coconut thatch or straw

Fig. 20. Disinfection

mat over the roof in order to keep the rearing house cool. However, when the temperature is very high it is not advisable to sprinkle water on the floor. This may increase humidity, which is generally high in hilly areas. High humidity and high temperature do not favour good growth of silkworms. The rearing stands are arranged on the lengthwise direction to accommodate, at least six stands on each side. Each stand can accommodate 10 to 11 bamboo trays of 4′ diameter. It is always advisable to sprinkle slaked lime mixed with bleaching powder in a ratio of 19:1, alround the rearing house as a disinfectant. This not only helps in checking the disease, but also helps in keeping air dry.

a) Disinfection

When the worms settle for first-moult, the late-age rearing house and its rearing appliances are cleaned. The next day they are disinfected with bleaching powder followed by 3% formalin. (*Fig. 20*). The total quantity of 3% formalin required for disinfecting rearing house is about 18 litres. Equal quantity is required for disinfecting verandah. For disinfecting rearing appliances additional 18 litres of 3% formalin is required. Thus, the total requirement of 3% formalin is 54 litres. Before disinfection, as suggested earlier, the doors and windows are closed. The rearing house should be opened 24 hours after disinfection to provide free ventilation and removal of formalin fumes.

Fig. 21. Bed cleaning with Net.

After first feeding of second-moult the beds are cleaned by using nets. The worms are transferred to round bamboo trays already disinfected in the late-age silkworm rearing house and shifted to late-age rearing house. (*Fig. 21*).

b) Rearing Environment

Late-age silkworms grow well, when ideal temperature of 24°C, to 26°C is provided. The temperature is reduced by 1°C at each stage starting at 26°C, so that at final stage, the worms enjoy the salubrious climate of 24°C. Such an ideal temperature of 24°C may not always be available, but one must put efforts to achieve optimum temperature.

Humidity plays an important role not only in preservation of leaves but also providing good environment for growth. Generally, the problem observed in hilly areas, in rainy season is that of high humidity. In such case, it is advisable to run a fan or put exhaust fan to throw out the humidity in the rearing house. It is always advisable to reduce the number of feedings when the humidity is quite high, as the leaves remain fresh for longer duration. The optimum temperature and himidity required for different ages in the later stages are given below:

Environmental Factor	3rd Stage	4th Stage	5th Stage and Spng.
Temperature	26° C-25° C	25° C-24°C	24°C-23°C
Humidity	75% - 80%	70% - 75%	65% - 70%

c) Quality of Leaf

The worms should be fed with fresh leaves as far as possible or should be fed with leaves which are preserved as fresh as possible. Feeding silkworms with yellow leaves or too tender leaves will naturally affect the physiology of the silkworm, thereby of exposing them to diseases. During 3rd instar the leaves are chopped to 4 to 5 sq.cm. size. During 4th instar and final stages entire leaves are fed to silkworms. It is also advisable to feed the silkworms with branches. Leaves remain fresh on the branches longer than plucked once.

d) Spacing

The proper spacing is an essential component for successful silkworm rearing. The optimum spacings suggested for different stages of silkworms are given below:

	No. of 4′ diameter trays	
Age of Larvae	**for 100 DFLs**	**for 250 DFLs**
3rd stage	6 to 12 trays	15 to 30 trays
4th stage	12 to 25 trays	30 to 62 trays
5th stage	25 to 50 trays	62 to 120 trays

Spacing indicated above is helpful in maximum growth of worms and harvesting good quality cocoons. Generally, when bivoltine silkworms are reared the population of worms per DFLs is high and thereby the space for rearing increases substantially. Hence, wider spacing is suggested when population is more than 40,000/100 DFLs.

Hilly areas enjoy more rains than the plains. When atmosphere is generally humid, there is a fear of outbreak of Muscardine disease. Hence, it is always advisable to use either formalin chaff or Resham Keet Oushad regularly. Further, rearing beds should be kept thin. Overcrowding of worms must be avoided. Thick rearing bed is detrimental to rearing, as it builds up

humidity beyond the tolerable limit, resulting in outbreak of disease. Hence, the bed should be kept always thin.

e) Leaf Quantity

As suggested earlier, entire leaves are fed to silkworms at 4th & 5th instars. However, it is suggested that the growth of silkworms should be controlled in such a way that the weight of 10 larvae just before spinning should not be more than 50 gms. The optimum requirement of leaves to rear 100 dfls is given below:

3rd instar	30 to 45 Kgs.
4th instar	85 to 125 Kgs.
5th instar	625 to 725 Kgs.

Even though the above norms are suggested, it is necessary to provide more leaves considering the larval population. Even though these guidelines are given, ultimate object is to get leaf cocoon ratio of 18:20 : 100 dfls when it is yielding 60 Kgs, the quantum of leaf used is 1,200 Kgs. Similarly, if the population of worms is thin 100 dfls may eat only 600 Kgs of leaf and yield about 30 Kgs of cocoons. The aim of feeding is to get rich harvest of cocoons thereby maintain leaves cocoon ratio of 20 Kgs to 1 Kg of cocoons. Cocoons with high weight like 2.0 to 2.5 grams with moderate shell weight give high renditta and low silk recovery, as such do not fetch high price as a commercial crop. Producing cocoons of 1.6 to 1.8 Gms and shell weight of 0.35 to 0.40 gms is good for commercial silk production.

20 Kgs to 1 Kg Cocoon

The larval duration in cooler conditions of hills may extend by a day or two. This can be avoided by maintaining optimum temperature, humidity and feeding of quality leaves right from brushing and care should be taken at moults.

f) Spinning

Silkworms grown under ideal conditions, stop feeding by 24 to 25 days of brushing and start spinning the cocoons. Generally, the worms loose bluish-white colour and acquire either deep-yellow or yellowish colour. Such worms crawl out of bed in search of space for spinning. They should be picked at the right time and put on mountages (*Fig. 22*). Generally, spinning is completed in about 72-73 hours. At this stage more labourers are required, because any delay in mounting worms lead to loss of silk and thereby building of improper cocoons. Every effort should be made to pick the ripe worms at proper time and mount them for spinning. Allowing unripe worms on mountages also lead to worms crawling helter-skelter and building improper cocoons, as its feeding is not completed. While mounting the silkworms, care should be taken to allow only ripe worms. Overcrowding of worms on Chandrikes lead to double cocoons viz., two larvae spinning a single cocoon. Such double cocoons are not fit for reeling and generally fetch low price. Hence, care should be taken to pick ripe worms properly and mount them for spinning. A chandrike of 4′ × 6′ accommodates 1,000 to 1,100 worms for spinning (*Fig. 23*). Hence, for spinning of worms of 250 DFLs about 100 chandrikes are required.

g) Harvesting of Cocoons.

Cocoons are harvested on the fifth or sixth day of spinning of maximum number of worms (*Fig. 24*). Harvesting the cocoons earlier to 5th or 6th day lead to the melting of cocoons due to pupal death. Such cocoons fetch low price. During the spinning also chandrikes should not be disturbed too much as frequent shaking lead to injury and death of pupae. The cocoons harvested must be cleaned. Dead flimsy cocoons and remnents of faecal matter are removed. Such good cocoons fetch higher price.

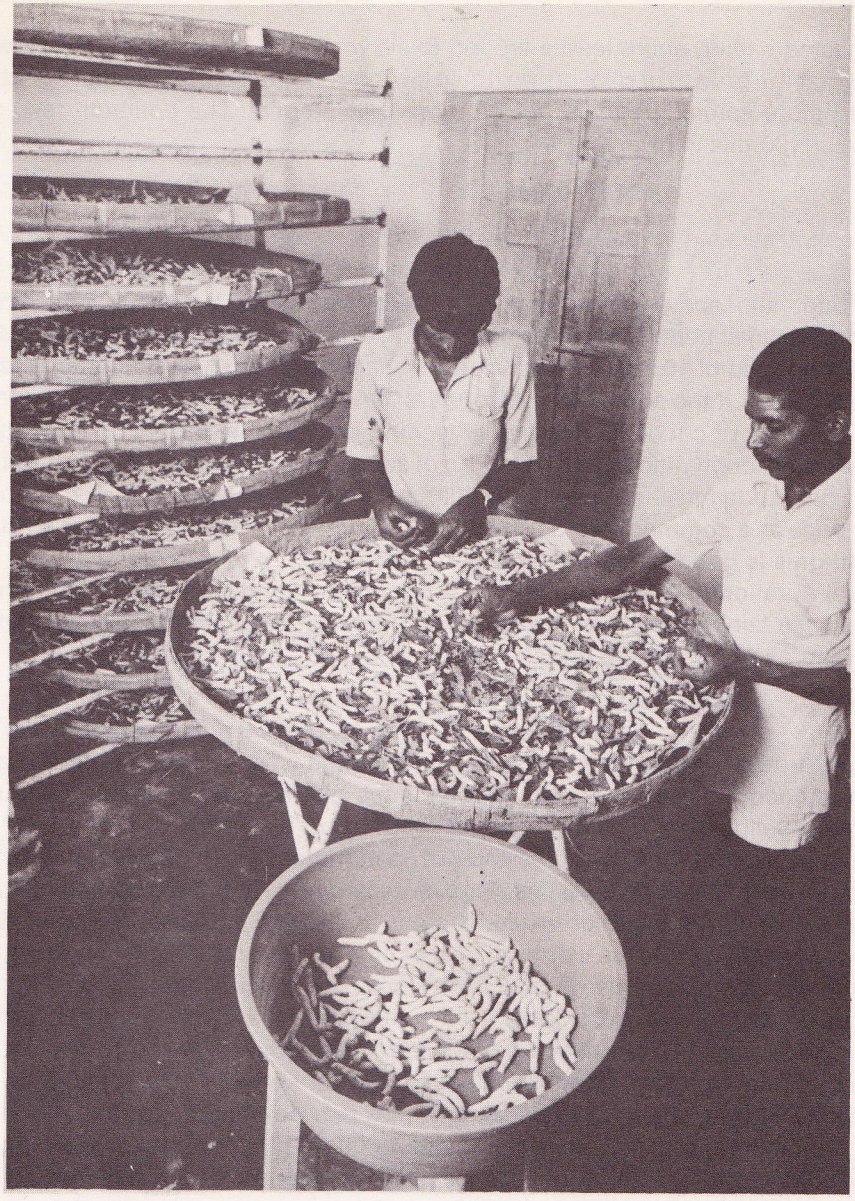


Fig. 22. Picking of Spinning Worms.

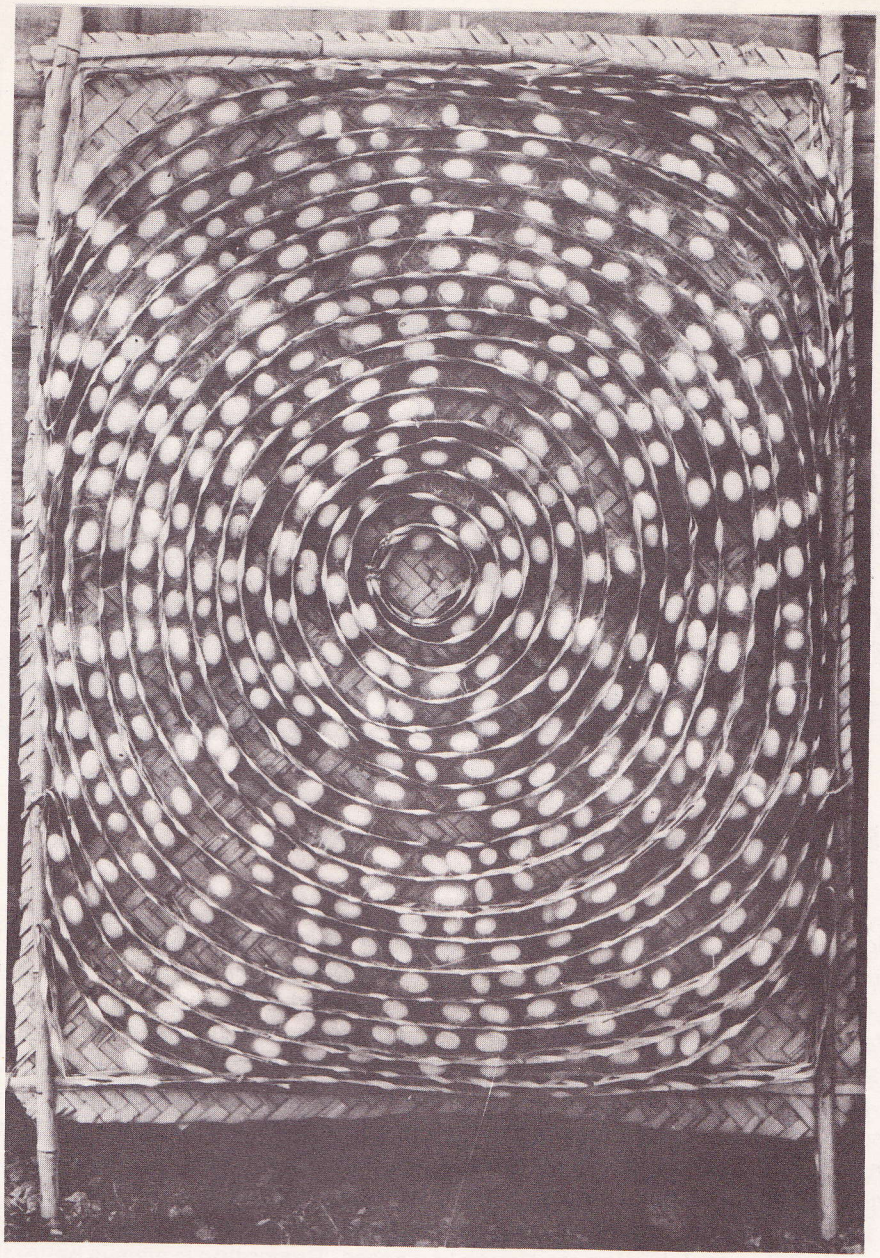


Fig. 23. Bivoltine cocoons on the mountages.

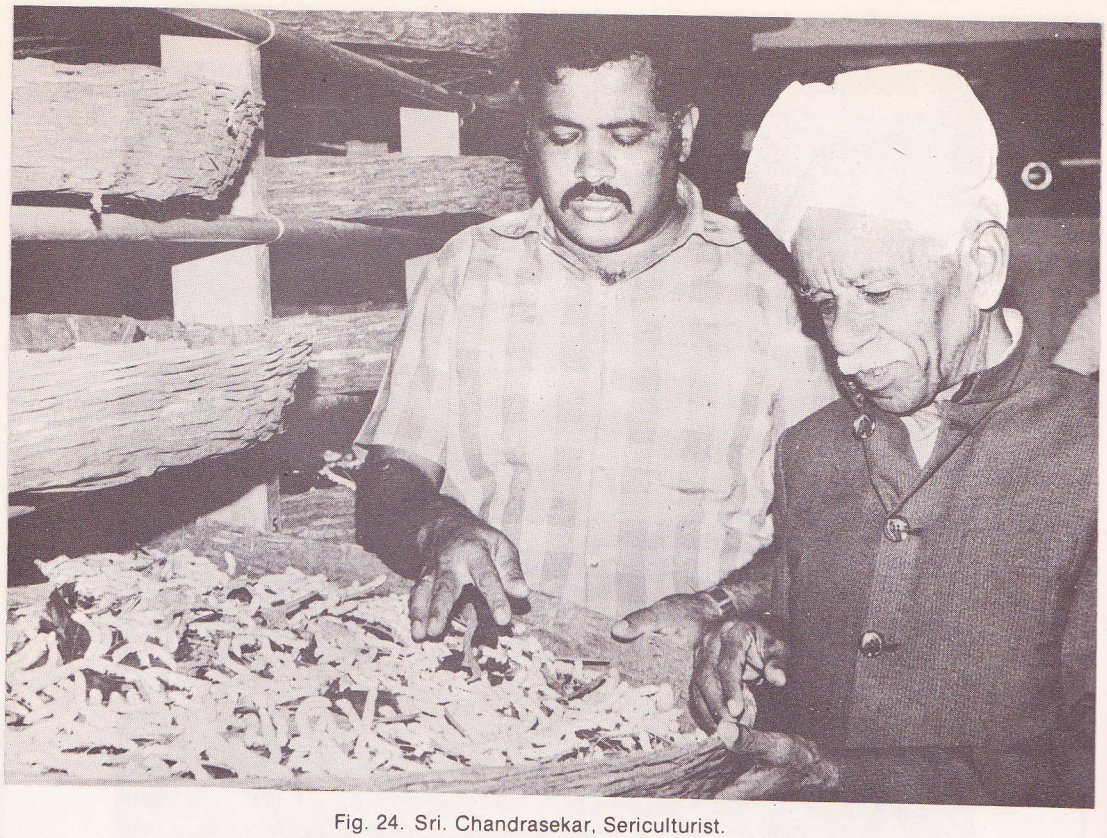


Fig. 24. Sri. Chandrasekar, Sericulturist.

VII. Silkworm Diseases and Sericulture Hygiene

In sericulture, to follow cleanliness and hygiene are as important as following the technologies. Sericulture hygiene contributes for control and prevent silkworm diseases and ensure success of crops. During silkworm rearing disease spread fast because of two main factors namely fast growth of silkworms and, large larval population in a limited space of tray. Hence it is always advisable to prevent diseases by following sericulture hygiene than controlling the disease. Disinfection of rearing house before starting silkworm rearing must be practiced as routine schedule. The workers must wash their hands in water and rinse them before feeding silkworms. During cleaning of silkworm beds, chop sticks and cleaning nets must be used. Application of lime and bleaching powder mixture all around the rearing house helps in keeping the area dry and disinfected. Rearing silkworms by proper hygienic conditions render them to grow strong and develop resistance to disease. 'Prevention is always better than cure' in silkworms. There are 4 main diseases of silkworms. They are Pebrine, Muscardine, Flacherie and Grasserie.

Pebrine is a protozoan disease and it is not only contaminative but also is "inherited". Procuring silkworm seeds free from diseases from authorised sources, strict disinfection and following sericulture hygiene can prevent the occurance of disease.

Muscardine is a fungal disease which is common in hill areas when atmospheric humidity and temperature are high, especially in rainy season. The worms die and develop white powdery fungal spores on the body. Use of formalin chaff, sprinkling of mixture of Dithane M-45 and lime and use of *"Resham Keet Oushad"* can prevent the disease. Dead worms must be burnt and should not be thrown helter skelter either in the rearing house or outside.

Flacherie disease is caused by improper rearing techniques and bad hygienic leaf and environmental conditions. Bacteria and viruses also cause disease. This disease being contaminative spread very fast in irregular rearing conditions which will make silkworm weak and susceptible to disease. Resham Keet Oushad may be used regularly as a preventive measure.

Grasserie is a disease accompanied with improper rearing, leaf and also due to viruses. Feeding late-age silkworms with tender leaf upset the physiology of silkworms and viruses attack them severey. The worms develop swollen segments and exude milky fluid from the body. Use of Resham Keet Oushad should be followed regularly to prevent the disease.

Pests

Uzifly is a pest on silkworms damaging the cocoons and making it unsuitable for reeling. The fly is similar to that of housefly but bigger in size. It makes its way into the rearing house and lay small white eggs on the larvae. The egg hatch and the maggot enters the body of the silkworm. After spinning of the cocoon, the uzi maggots pierces through the body of the pupa and cocoon, killing the pupa and crawls in search of crevices in the rearing house to pupate and emerge later as a fly. Use of net for covering the rearing area, providing wiremesh to windows and use of uzicide can prevent the attack of Uzifly.

VIII. The Hilly Areas Hold the Promise of Bivoltine Silk Production

Rearing bivoltine silkworms in Malnadu areas of Karnataka such as Hassan, Chickmagalur, Shimoga and Sirsi areas is found to be a lucrative agrobased profession. Many of the small and marginal planters are practicing sericulture to augment their income. While coffee provides an annual return; mulberry cultivation and silkworm rearing provides continuous and uninterrupted monthly return to these farmers. This is made possible by dividing the mulberry plantation into two units and adopting rearing of silkworm throughout the year by taking mulberry leaf from the alternative plots. Even though mulberry plantation does not provide such lucrative return as in coffee, it surely provides uninterrupted return without much risk. Failure of blossom shower may affect surely the return from coffee plantation, but mulberry continues to provide foliage for quality cocoon production throughout the year. Mulberry is an ideal money earner and generates additional income to the coffee planters.

The production of cocoons per unit area in Malnadu of Karnataka is almost double than that of plains. One acre of mulberry plantation yield as mush as 500 to 600 Kg. of bivoltine cocoons as compared to 350 to 400 Kg cocoon, per acre in Plains. While multivoltines with low silk recovery are generally reared in plains, the farmers of Malnadu are rearing bivoltines with rich silk content.

To cite few examples, Farmers like, Shri Chandrashekar of Biligaravally village of Alur Taluk in Hassan district has taken seven crops annually in his 1.5 acres of mulberry plantation. By rearing 1,100 DFLs of bivoltines, he has harvested about 625 Kg of cocoons during the first year of plantation which can be doubled during the next year.

Shri Mahesh of Malagalale of Alur Taluk in Hassan district has planted one acre mulberry. His plantation is two years old. He has taken 8 crops a year and harvested about 650 Kg of bivoltine cocoons during the second year of plantation. Considering the good return from mulberry he has programmed to plant mulberry as shade trees in his new coffee plantation.

Shri Gopal Bhat of Nidagarahalli in Hassan district has taken 15 crops in his one acre plantation during two years of plantation. He is taking about 100 DFls for each crop. He has harvested an average 60 Kg/100 DFLs and 600 Kg cocoons/acre during second year. His highest yield accounted was as high as 80 Kg and the lowest was 55 Kg/100 DFLs.

Shri Walter Lobe of Bijuvally village of Mudagere Taluk in Chickmagalur has one acre of mulberry and has harvested 320 Kgs of bivoltines in a year.

Shri Anne Gowda of Baiduvalli in Chickmagalur district has 1.2 acres of mulberry and has obtained 505 Kgs of bivoltine cocoons during his second year of plantation. His average yield works out to about 53 Kgs/100 DFLs.

Shri Ramakrishna Naik of Sirsi has harvested over 500 Kgs of bivoltine cocoons in his one acre of mulberry garden in one year.

Hilly areas of Karnataka, Tamilnadu and Kerala hold high promise for rearing of bivoltine and production of rich bivoltine cocoon leading to production of international grade silk. The potentialities of these areas should be properly harnessed for production of international bivoltine silk in the country. Even if every planter takes to an acre of mulberry plantation, production of 1,000 tonnes of international grade silk can be achieved within a short span of time. Celubrious climate, favourable ecological conditions and availability of educated farmers to adopt new technologies of bivoltine silkworm rearing should be fully exploited for production of bivoltine silk. Hilly areas of South India is on the threshold of *'White Silk Revolution'*.

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