A GUIDE FOR BIVOLTINE SERICULTURE

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Preface

Bivoltine silkworms produce better cocoons with high silk content. Bivoltine silk is also of better quality and international standard. Basically, bivoltine silkworms are from temperate region and if they are to be raised under rigorous tropical conditions one has to make appropriate modifications and observe certain conditions. Although, the Central Sericultural Research and Training Institute, Mysore way back in 1970s evolved appropriate sericulture techniques to raise highly productive bivoltine cocoons under South Indian conditions, only a small section of the farmers are reaping benefits of the same. The object of this booklet is to highlight various technological aspects of bivoltine sericulture in the form of questions and answers. It is hoped that this will serve as a practical guide. At the end some Do's and Don'ts for bivoltine sericulture have also been given.

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Date:

1. General

1.1 Why to go for bivoltine sericulture?

Higher productivity and consequently higher return is the guiding factor for any venture. From this point of view there is no doubt that bivoltine breeds/crosses have a higher potential of both leaf to cocoon and cocoon to silk conversion. Reared properly 100 dfls of bivoltine with a single cocoon weight of 1.8 gm and 400 larvae per dfl. spinning cocoons should give an yield of 72.00 kg or say 70.00 kg of cocoons per 100 dfls and this is possible to achieve too. From 200 dfls of bivoltine reared per acre per crop one should thus be able to harvest about 140.00 kg of cocoons. Now, on the same amount of leaf 250 dfls of cross-breed dfls may be possible to be reared. Taking 50 kg of cocoons per 100 dfls as a good yield for cross-breed layings, 250 dfls at the maximum could give about 125.00 kg of cocoons. In addition bivoltine cocoons have a lower renditta around 7 to 8 against about 9 to 11 in the cross-breeds. The former also gives better quality silk. Or otherwise bivoltine dfls could:

a) Yield more and better cocoons per unit quantity of leaf consumed.
b) Yield more and better silk per unit quantity of cocoon reeled.

and consequently bring higher returns to the bivoltine rearers.

1.2 Is this happening in the field?

The answer is both yes and no. While all the farmers are not able to reap the benefit of this new technology, a good number of them are doing so also This has been amply detailed in the book-lets Yes Bivoltine" and "Sericulture practices for the hilly areas of South India" brought out by the National Silkworm Seed Project. A few examples of success in the farms and with farmers are given below:

TABLE-1a: P3 Basic Seed Farm, Nagamangala from 1981-87 (Karnataka)

Irrigated: 4.5 acres. Rainfed: 2.0 acres

Year	Race	No. of dfls brushed	Actual yield (kg)	Yield/100 dfls. (kg)
1981-82	KA, NB4D2, NB7, NB18	691	569.90	83.80
1982-83	NB7, NB18			
1983-84	—do—	3,367	2,512.80	74.35
1984-85	—do—	2,740	2,303.60	84.20
1985-86	—do—	2,145	1,873.95	87.37
1986-87	—do—	3,291	2,466.59	74.95
	—do—	2,169	1,620.51	74.70
		14,403	11,347.34	78.78

TABLE-1b: P3 Basic Seed Farm, Yelegiri Hills, Tamil Nadu

Area under Mulberry: 6.0 acres

1983-84	KA, NB7, NB18, NB4D2	1,218	1,045.8	86.22
1984-85	—do—	1,992	1,683.7	84.52
1985-86	—do—	2,404	1,903.0	79.46
1986-87	—do—	1,919	1,183.6	74.70
		7,533	5,016.1	77.20

TABLE-1c: Performance at Farmer's Level

Name of Farmer: Shri Virupaksha
Village: Hassan, Karnataka
Mulberry Garden: 0.5 acres

Date of brushing	No. of dfls. reared	Total yield (kg)	Yield/100 dfls. (kg)
April 1986	52	40.6	78.1
August 1986	30	27.0	90.0
September 1986	75	47.0	62.7
November 1986	69	52.0	75.4
March 1987	90	65.0	72.2
	316	231.6	73.3

Name of Farmer:	Shri H. S. Nagaraju		
Village:	Chunchuganapally, Hosur Tq., Tamil Nadu		
Mulberry Garden:	1.5 acres		
1985-86:			
September 1985	100	68.0	68.0
September 1985	100	65.0	65.0
November 1985	100	78.0	78.0
November 1985	90	57.0	64.0
December 1985	175	126.0	72.0
February 1986	100	66.9	66.9
March 1986	200	144.0	72.0
	865	604.9	69.9

1.3 What are the pre-requisites for successful bivoltine cocoon production?

Basically there are 4 pre-requisites for successful bivoltine cocoon production. They are:

1. **Raising a good mulberry plantation to produce quality mulberry leaf.**
2. **Rearing silkworms by adopting proper rearing technologies such as methods to provide optimum temperature/ humidity to rearing beds, spacing, etc., i.e, rearing climate management.**
3. **Procurement of good quality silkworm seed from recognised grainages, and**
4. **Thorough initial disinfection of the rearing house and rearing appliances to prevent entry of pathogens and maintenance of hygenic conditions during rearing.**

Dr. Matsumara, noted Japanese sericulture scientist, based on six years data with 667 samples at farmer's level, arrived that the following are the important factors contributing for successful harvest of bivoltine cocoon crops:

Mulberry leaf	**38.2%**
Climate	**37.0%**
Rearing technique	**9.3%**
Silkworm race	**4.2%**
Silkworm eggs	**3.1%**
Other factors	**6.6%**

(MYASHITA, 1986)

(Courtesy: Western ghats as a Bivoltine Region: Ind. Silk, Jan. 1988)

Thus, mulberry leaf and climate play very significant roles in determining the crop success followed by the rearing technique, silkworm race or breed, silkworm eggs, etc.

2. Mulberry

2.1 How to raise a good mulberry plantation?

Mulberry cultivation is the first step in sericulture and raising good and healthy plantation is the base for bivoltine sericulture.

June-July months are ideally suited for mulberry planting. Mulberry can be cultivated both under rainfed and irrigated conditions. However, mulberry grown under irrigated conditions yields better quality mulberry leaf in larger quantity.

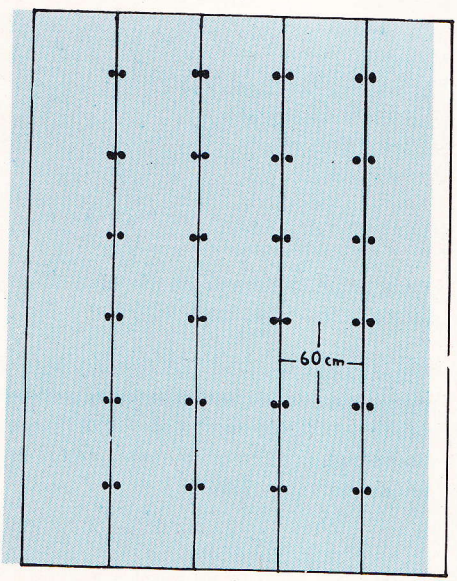
The density of plant population plays a key role in mulberry leaf yield and its quality. Under irrigated conditions, mulberry can be planted in row system or pit system. In

Row system of plantation is not suitable for bivoltine rearing as due to very close planting leaves do not get enough sunshine to mature.

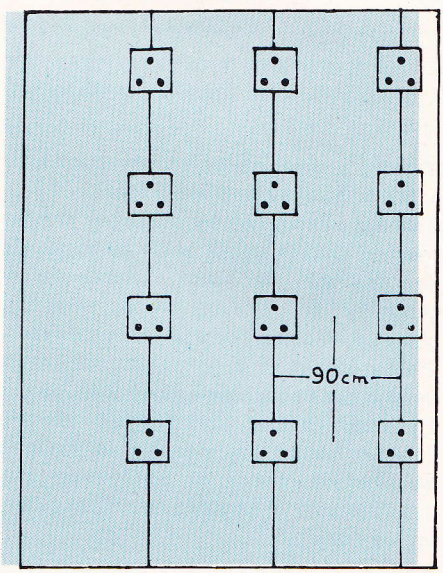
In pit system cuttings are again planted in twos but at a distance of 60 cm x 60 cm. Furrows are made 15 cms deep for easier water per-colation. Pit system of plantation is recommended for bivoltine sericulture.

For high rainfall and hilly areas, 90cmx90cm spacing between mulberry plants is ideal.

In Plains



In Hilly areas



Layout of Plantation

A light hoeing and weeding is carried out 2 months after planting. A second weeding is done after another 3 months.

After 3 months of planting 50:50:50 NPK is applied and irrigated. 6 months after planting first harvest of leaf is done by leaf plucking and 50 kg N fertiliser is given. Further 2 crops are taken in the remaining 6 months and bottom pruning is done at 20 cm above the ground level for the 2'x2' Plantation in the plains. For the 3'x3' plantation in the hilly region, pruning should be done at 30 cm height to be followed by pruning at 45 cm height during the subsequent years.

2.2 Which mulberry variety is good?

The two principal mulberry varieties currently used in South India are local and *Kanva-2*. From the qualitative and quantitative aspects, Kanva-2 mulberry variety is far superior to the local variety. *S-54* is a new mulberry variety developed recently and is being popularised for irrigated conditions.

2.3 What fertilisers to be applied to irrigated mulberry garden?

Annually, at the time of bottom pruning in row or pit system or pruning at crown height in case of hilly areas, application of organic manure is a must. The farm-yard-manure is necessary as it enriches water holding capacity and increases organic matter of the soil. It keeps the soil loose, friable and makes the soil more fertile. Further it supplied the micro nutrients and trace elements like Boron, Manganese, Copper, Zinc, Cobalt and Nickel essentially required not only for plant growth but also for the healthy growth of silkworm which are not possible to be obtained from chemical fertilisers. A chart showing their availability in fertilisers and in the FYM is given in Table-2.

FYM should be applied annually @ 20 mt per hectare.

In addition, chemical fertilisers should be applied as per the schedule.

Fertiliser Application Schedule

Fertiliser application for pit system (2′ × 2′) of mulberry: 280 N : 120 P : 120 K. kg/ha.

Dose	How much to apply	When to apply
1st application	8 bags (400 kg) of 15 : 15: 15	1 month after pruning
2nd application	1¾ bags (90 kg) of urea	3 weeks after 1st leaf harvest
3rd application	1¾ bags (90 kg) of urea	3 weeks after 2nd leaf harvest
4th application	8 bags (400 kg) of 15 : 15: 15	1 mongh after 2nd pruning
5th application	1¾ bags (90 kg) of urea	3 weeks after 4th leaf harvest
6th application	1¾ bags (90 kg) of urea	3 weeks after 5th leaf harvest

Fertiliser application for 3′ × 3′ mulberry in hilly areas: 250 N + 100 P + 100 K. kg/ha.

1st application	50 kg N + 50 kg P + 50 kg K	1 month after pruning
2nd application	50 kg N	15 days after leaf harvest
3rd application	50 kg N + 50 kg P + 50 kg K	3 weeks before 3rd leaf harvest
4th application	50 kg N	15 days after pruning
5th application	50 kg N	1½ months after 4th leaf harvest

TABLE-2: Micronutrients and Trace Elements availability in fertiliser and farm-yarn-manure

Parts per million in dry material:

	B	Mn	Cu	Zn	Co	Ni
1. Sodium Nitrate	0	8	3	1	0	0
2. Ammonium Sulphate	6	6	2	0	0	0
3. Super Phosphate	11	11	44	150	4	13
4. Potassium Sulphate	4	6	4	2	0	0
5. Potassium Cloride	14	8	3	3	1	0
6. Farm-Yard Manure	20	410	62	120	6	10

2.4 How to prune the mulberry garden?

Pruning should be done by cutting the stems of the plants with a sharp pruning sickle/knife without damaging the stem or pealing off the bark. Pruning is resorted to the different systems of mulberry plantation as under:

Pit system (60 cm x 60 cm)

Twice in a year: Once with the commencement of South West Monsoon (early June) and; second after 3rd leaf harvest in late November plants are cut 10-12 cm above the ground level. Latest studies however, show that for this type of planting pruning at 45 cm. (1½ ft.) above the ground level followed by step up shoot harvest leaving each time 2-3 buds give the best result.

Hilly areas (90 cm x 90 cm)

Pruning is to be done 45 to 60 cm (1½ to 2') above the ground level. 1st pruning is to be done in June with the onset of the South-West monsoon and the 2nd pruning is recommended in October following the leaf/shoot harvest.

2.5 What are the schedules of cultural operations for mulberry?

Schedule for cultural operations for irrigated mulberry

PIT SYSTEM

Operation	Timings
1. 1st bottom pruning	With the commencement of the South-West monsoon rains (early June)
2. 1st weeding and inter-cultivation	Within a week after pruning (2nd week of June)
3. Application of bulk organic manure at the rate of 20 tonnes/hectare and incorporation of the same	Within a fortnight after pruning (3rd week of June)
4. 1st dose of fertiliser application	Within a month after pruning (early July)
5. 1st harvest of leves	By leaf picking (mid August)
6. 2nd weeding and inter-cultivation	Within a week of last harvest (3rd week of August)
7. 2nd dose of fertiliser application	Within 3 weeks of last harvest (2nd week of September)
8. 2nd harvest leaves	By leaf picking (early October)
9. 3rd dose of fertiliser application	Within 3 weeks of last harvest (4th week of October)
10. 3rd harvest of leaves	By leaf picking (late November)
11. 2nd bottom pruning	Immediately after 3rd leaf harvest (late November)
12. 3rd weeding and inter-cultivation	Within a week after 2nd pruning (1st week of December)
13. 4th dose of fertiliser appplication	Within a month after 2nd pruning (3rd week of December)
14. 4th harvest of leaves	By leaf picking (early February)
15. 5th dose of fertiliser application	Within 3 weeks after last harvest (4th week of February)
16. 5th harvest of leaves	By leaf picking (1st week of April)
17. 4th weeding and inter-cultivation	Within a week after last harvest (2nd week of April)
18. 6th dose of fertiliser application	Within 3 weeks after last harvest (late April)
19. 6th harvest of leaves	By leaf picking (late May)

Schedule of operation of Mulberry in Hilly areas

90 cm x 90 cm

	Operation	Schedule
1.	Annual basal pruning (45 to 60 cm above the ground level)	After commencement of South-West Monsoon rains (4th week of June)
2.	Weeding/intercultivation	1 week after pruning
3.	Sowing of green manure crops like horse gram	2nd week after pruning
4.	1st dose fertiliser application	1 month after pruning (4th week of July)
5.	1st leaf harvest	Mid August
6.	2nd dose of fertiliser application	Late September
7.	2nd leaf harvest/branch cutting following by pruning	Mid October
8.	Weeding/mulching of green manure crop	3rd week of November
9.	Sowing other green manure seeds	4th week of November
10.	3rd dose of fertiliser application	4th week of November
11.	3rd leaf harvest	1st week of January
12.	Application of FYM	3rd week of January
13.	4th dose of fertiliser application	1st week of February
14.	4th leaf harvest	1st week of March
15.	Weeding/mulching of green manure crop	2nd week of April
16.	5th dose of fertiliser application	2nd week of April
17.	5th leaf harvest followed by pruning in June	Mid May

2.6 How to control mulberry pests and diseases?

Although mulberry is a hardy plant, some times the diseases/pests cause afflictions and render the leaves unsuitable for rearing silkworms. The following table gives methods to check these problems:

Pests	Control
1. Bihar hairy catterpiller	Spray 0.2% DDVP
2. Scale insects	Spray 0.05% Malathian or Nuvacron
3. Plant Lice	Spray 0.02% DDVP
4. Hopper burn due to leaf hoppers	Spray 0.1% Rogor
5. Tukra	Spray 0.01% Parathion
Diseases	
1. Leaf spot	Spray 0.1% Bavistin or Benlate
2. Powdery mildew	Spray 0.2% Karathane
3. Root knot	Apply 3 kg Aldicarb (Tenik 10 g) per ha. or 1 ton neem oil cake/ha/ year in 4 equal split doses

2.7 What will be the leaf harvest time and crop pattern in irrigated mulberry plantation?

Season	Leaf yield/ha. (in kg)	Rearing capacity (in dfls)
In Plains		
August	7,500	1,000
October/November	7,500	1,000
January	6,000	800
March/April	7,000	900
June	7,000	900
	35,000	4,600

In Hilly Areas		
August	5,500	550
October	4,500	450
January	4,500	450
March	5,000	500
May	5,500	550
	25,000	2,500

The mulberry plantation is fully established in the first year and reaches maximum yielding capacity from the second year onwards. The leaf yield per crop is more or less uniform through out the year except the cold winder season.

3. Rearing

3.1 Now that the mulberry plantation is ready, how to start and have a successful rearing?

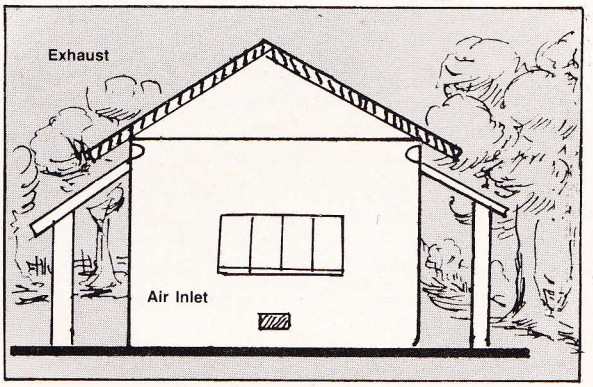
It was told in the beginning itself that after the mulberry leaf, the second largest determining factor for successful rearing is the climate. The climate does not just mean the temperature and humidity of the area, but the climate or environment prevailing in the rearing room and around the rearing bed. This is to a great extent determined by the position, type and provisions made in the rearing house.

3.2 Is bivoltine rearing possible in the plains and plateaus round the year?

It depends on the availability of good leaf and temperature and humidity prevailing in an area. If the leaf growth is good and the temperature and humidity not exceeding 30°c and 80%, it is possible to rear bivoltine silkworms since it has been observed that upto 5 degrees of temperature and 10% of humidity can be manipulated inside the rearing house.

3.3 What type of rearing house is ideal for rearing bivoltine silkworms?

Whether bivoltine or miltivoltine a separate rearing house is always preferable than rearing in the dwelling houses. It is all the more essential for bivoltine rearing. The rearing house should be high at least 12 to 15' preferably with a false ceiling as well as thick walled to protect from radiating heat and cool. It should have sufficient number of windows also to permit cross ventilation. It should have ventillators both below and above to provide an air current. It can also be better if there are trees around the rearing house particularly on the Western side which could keep the house cooler. Verandah all around could also insulate the house from fluctuating temperature. All these should be kept in mind while constructing a rearing house. Diagram of an ideal rearing room is given below:



3.4 What should be the size of the rearing room?

In the normal stand and trays rearing method 20 sq. ft. floor areas is kept for 10 dfls or otherwise a room having a floor area of 400 sq. ft. (20' × 20') is able to sustain the rearing of about 200 dfls. Depending upon the volume of rearing, the size of the room should be determined.

3.5 What are the rearing equipment required

The requirement of rearing equipment for 200 dfls. is given below. It may have to be increased according to the increase in the volume of rearing.

Requirement of rearing equipment for 200 dfls.

	Quantity in No.
Chawki rearing:	
1) Wooden trays (4' × 3')	8
2) Chawki stand	1
3) Ant-wells	4
4) Feeding stand	1
5) Basin stand	1
6) Chopping knife and board	1 each
7) Leaf chamber	1
8) Foam strips (4' × 3')	16
9) Hygrometer (Dry and wet bulb thermometer)	1
10) Litter Basket	1
11) Heater	1
12) Cleaning nets	16
Late age rearing	
1) Bamboo rearing tray (4' dia)	80
2) Rearing stands (5' × 2.5' × 7.5')	8
3) Ant-wells	32
4) Bamboo mountages (6' × 4')	80
5) Sprayer	1
6) Feeding stands	2
7) Basin stands	2
8) Leaf chopping board and knife	1
9) Hygrometer (Dry and wet bulb thermometer)	1
10) Litter baskets	2
11) Bed cleaning nets	160

3.6 Are there some steps to be taken before the start of the rearing?

Before the start of each rearing including the initial, it is very essential to disinfect the rearing row and equipment.

3.7 What is disinfection?

Disinfection is the destruction of disease causing germs and that is done by exposing the germs to some chemicals known to have germicidal effect.

3.8 What are those chemicals and from where can they be procured?

Commonly used disinfectants are:

1) Formalin
2) Para formaldehyde
3) Bleaching powder
4) Sodium hypochlorite and
5) Lime

The first four can be obtained from the chemists and the fifth one from the merchants dealing with lime. It may, however, be better to consult the nearest sericultural centre for guidance in the matter.

3.9 How to prepare the disinfectants?

Out of five, the more commonly used disinfectants are formalin and bleaching powder. Active chlorine component of the bleaching powder is known to inactivate the virus with in three minutes and 2% formalin solution in 15 minutes. The effectiveness of formalin can be increased considerably by adding 0.5% lime to the solution. Methods of preparation of formalin, bleaching powder and sodium hypochlorite solution are given below:

Formalin soln 2%

Commercially available formalin contains 36 to 40% formaldehyde. To prepare a 2% solution from 36% the formula used is

36 − 2 = 17 2

parts of water added to 1 part of commercial formalin

For a rearing house of the size 20′ × 25′ × 12′ approximately 18 litres of formalin solution are required, *i.e.*, 17 litres of water and one litre of commercial formalin. Similarly for a house of 20′ × 20′ × 12′ the requirement of solution comes to about 14.4 litres containing 13.6 litres of water and 0.8 litres of commercial formalin. Almost another equal quantity is required for disinfecting the rearing equipment.

Bleaching Powder 5%

For making a 5% bleaching powder solution, 50 gms of bleaching powder is added to 1 litre of water. 20 to 25% chlorine being present in bleaching powder, a 5% solution will give about 1 to 1.25% of active sodium hypochlorite 0.5% ingredient.

Sodium hypochlorite is used as a 0.5% solution.

All the above are used as spray.

3.10 What about fumigation?

Fumigation can be done only if the rearing room is air-tight. In this process the rearing equipment after cleaning and washing are put inside the rearing room for fumigation and the room is then hermitacally sealed. The quantum of formalin required is determined as per the room size. The same is diluted 4-5 times and allowed to evaporate inside the room in a pan kept on a chorcoal oven or electric stove. The advantage of fumigation is that it does not require the handling of formalin and as a fumigant can reach all the nook and corner of the room. Further, the disinfection of the room and the equipment can be taken up together.

Fumigation can be done by utilising paraformaldehyde also which sublimates on heating releasing formaldehyde fumes. To fumigate an area of 10 cubic metres about 60 gms of paraformaldehyde are required.

3.11 From where to get good quality bivoltine silkworm seed (eggs)?

The quality of seed is determined by a number of factors like good parental breeds, combination of parents, their good raising as seed crop, preservation and processing in the grainage, etc. Taking all these points into consideration, it may be better to collect egg from the Government grainages. Good quality silkworm seed can be obtained from the grainages of National Silkworm Seed Project and State Government grainages.

3.12 How to incubate the eggs?

To obtain healthy developmet of the embryo and uniform hatching silkworm eggs should be incubated under optimum temperature (25°C) and humidity conditions (80% RH). Eggs should always be transported from grainages during the cooler hours of the day. Later on, they should be spread in a single layer on the paraffin paper in the wooden trays. Wet foam pads should be kept all around the eggs covered by another paraffin paper.

3.13 How to get uniform hatching?

To get uniform hatching, one day prior to hatching the eggs should be kept in darkness and on the day of hatching they should be exposed to light. This ensures uniform hatching of all eggs at a time. Newly hatched larvae should not be starved or refrigerated.

3.14 How to brush newly hatched silkworms?

Brushing is the process of separating the newly hatched larvae gently and carefully from the egg sheets. After attaining uniform hatching, the tender mulberry leaves of suitable quality are selected, cut into 0.5 x 0.5 cm square pits ad sprinkled on newly hatched larvae. After 10-15 minutes egg sheets together with leaf bits are turned down and worms with leaves are shifted to paraffin paper sheet. Now hold the egg sheets 2-3" above rearing bed and gently tap the sheet to separate still left over larvae. By sprinkling some more leaf bits, the rearing bed is made. Instead of taking layings and then brushing, it is possible now to get chawki reared worms also.

3.15 What is chawki rearing?

Each rearing stage has its own requirments of leaf type, temperature and humidity. Based on this the whole rearing period has been divided into two major parts, the earlier one covering upto the

second or the third stage requiring softer leaves and higher temperature and humidity and the later one covering the later two stages requiring mature leaf and lower temperature and humidity. Rearing care required during the earlier stages being more, it is often done collectively on a co-operative basis or departmentally taking more care. Worms are then distributed amongst the rearers. This has come to be known as chawki rearing. In all advanced sericultural countries rearers prefer to get chawki reared worms than silkworm eggs.

3.16 How to select mulberry leaves for rearing young age rearing?

Mulberry leaves for young age silkworms must be soft, rich in water content, proteins, carbohydrates, etc. The correlation of moisture in the top tender leaves and the growth rate of young age silkworms and moulting ratio is well established. For young age rearing the leaves are plucked and used as follows:

i) From the largest glossy leaf at the tip, 3 to 5 leaves are plucked downwards for the I instar.
ii) 6 to 10 leaves are suitable for the II age rearing
iii) Remaining tender leaves are suitable for III age silkworms

3.17 What about the leaves for the late age rearing?

Leaf harvest is done either plucking individual leaves are by branch cutting which is otherwise known as shoot harvest. In case of leaf plucking, the whole leaf can be fed to IV to V stage worms without chopping.

In rainy season, depending on the rearing room humidity, leaf can be cut into two and fed to the worms. This is undoubtedly a better method where each leaf can be picked up according to the suitability. It is however, slightly labour intensive. In case of shoot harvest the tips must be taken off and then the shoots cut into convenient length to accommodate them in the rearing trays. This makes the bed cleaning easier. *For bivoltine rearing feeding of well developed mature leaves to the late age worms is a must.*

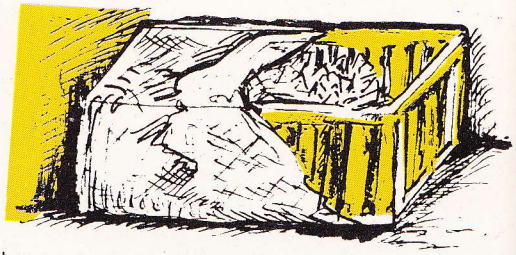
3.18 What about the seasonal change in leaf maturity?

Adjustment in leaf maturity in relation to season is very much desirable in silkworm rearing. Postponement of leaf harvest by about 15-20 days during the rainy season could improve the crop yield. In summer, the reverse is true.

3.19 How to transport the leaves?

Under tropical conditions, leaf driage is faster. Leaf harvest should be made in early morning hours and in evening hours. A wet gunny cloth lined bamboo basket is ideal to collect leaves and to transfer them to the rearing house.

3.20 What is the correct method to store the leaves?



Harvested mulberry leaves are stored under high humidity (particularly during hot months) and low temperature. Leaves are stored in specially made wooden chambers covered with wet gunny cloth by priodic spraying of water. However, large quantity of leaves could be stored in gunny cloth (wet), on floor in the rearing houses. Sprinkling of water over leaves may be necessary in summer months.

3.21 How to feed the worms?

Feeding four times a day is ideal both for the early as well as the late age worms. For late age worms, it is desirable to reduce the frequency in rainy seasons and increase the same during summer months. A judicious increase in the quantum of feed during cooler hours is desirable. The feeding time should be 5.00 AM, 11.00 AM, 4.00 P.M. and 10.00 PM.

3.22 What are the optimum temperature and humidiy conditions for bivoltine silkworm rearing and how to maintain them?

The temperature and humidity requirements of different stages of silkworms are indicated below:

Factors	I age	II age	III age	IV age	V age
Temperature (°C)	27	27	26	24-25	23-24
Humidity (RH)	85-90	85-90	80	75	70

If the rearing room temperature is below the temperature required the simple way is to heat-up the rearing room and raise temperature. Electric room heaters of charcoal stove can be used for this purpose. Under South Indian conditions, such situations are limited to night times only, especially during winter months. The temperature is more often above the optimum. To bring down the temperature windows should be kept open during night and early moring and closed at noon. Lower and upper ventillators should be opened, lower one to such in the cooler air from below and the upper one to release the same. Proper designing of rearing building, use of thick walls and roof, providing adequate aeration facilities to ensure free circulation of air, etc. could help in the matter.

Regulation of humidity for young age silkworms is achieved through the use of paraffin paper cover and wet foam pads or wet paper pads. It must be understood that humidity above 90% is not at all desirable for rearing bivoltine silkworms. In rainy season, when the room humidity is above 90% use of wet foam pads and piling up of rearing trays is not necessary. Paraffin paper cover or seat paper may also be dispensed with judiciously when the room humidity is very high.

Humidity plays a very important role in the success of bivoltine silkworm rearing. The humidity requirements of late ages are different from that of early instars. The humidity requirement during feeding and

Factors	I age	II age	III age	IV age	V age
Size of leaf (in cm) 2	0.5-2.0	2-4	4-6	Entire	Entire
Quantity of leaf (in kg)	3.5	10	50	100-125	800-900
Cleaning/day	1	2	3	Daily	Daily
No. of 3' dia. round bamboo trays	3	7	10-15	20-25	40-50

mounting stage are different. Comparatively high humidity is maintained during feeding period to maintain the freshness of leaves supplied for sufficient consumption by preventing withering of leaves in the rearing bed. However, comparatively low humidity is preferable during moulting stage.

3.23 What are the other aspects of the rearing schedule for bivoltine silkworm rearing?

Besides temperature and humidity the following are the other important aspects in bivoltine silkworm rearing (for 100 dfls).

Since young silkworms are delicate cotton or nylon nets are applied for cleaning just one feed prior to cleaning and cleaning done by lifting the worms along with net and leaves.

3.24 What are the cares to be taken during moult?

Silkworms moult four times during its larval stage. During moulting the rearing bed should be gently spread and kept open. This facilitates drying of left over leaves and moulted larvae are prevented from eating left leaves. The IV moult is characteristic and duration is slightly prolonged (30 hrs) compared 1st to 3rd moults. If there is high humidity in the rearing room a thin layer of lime powder could be dusted on rearing bed prior to stopping feed.

3.25 How to give optimum spacing for bivoltine silkworms?

Spacing for bivoltine hybrids

Instar		No. of larvae per sq.ft.	Bed area per sq.ft.
IV	starting	333	120
	ending	166	240
V	starting	166	240
	ending	83	480

Like the quality of mulberry leaf, the spacing of worms in rearing bed is very crucial factor in bivoltine silkworm rearing. More than 93% of leaf feed is given during IV and V instar. Over-crowded rearing leads insufficient feed consumption, poor growth and succeptibility to diseases. The overall result will be low yield of cocoons of inferior quality. Over spacing tends to leaf wastage and higher leaf cocoon ration. Therefore, optimum spacing based on the growth potential is given below for realising best cocoon crop:

The spacing should always be increased in proportion to the growth of larvae.

3.26 What about air current in the rearing room?

In the rearing room the air is apt to be polluted by carbon monoxide, carbon dioxide, ammonia, sulphurdioxide, etc., produced by the working men, silkworms, mulberry leaves fermentation of litter, burning of charcoal, etc. These injurious gases often affect the larval health and make them succeptible to various diseases.

Thus proper air current not only helps in providing fresh air required for silkworms but also regulates rearing room temperature and humidity. This can be done by providing ventilators air inlets slightly above the floor level and air outlets at the top.

3.27 What should be the temperature and humidity for spinning silkworms?

The temperature during spinning is a very important factor as it affects the spinning efficiently and quality of cocoons. So also the humidity factor. The ideal temperature and humidity during spinning is 23-25°C and 60-70% R.H. Since great amount of water is discharged during spinning process, ventillation during first half of spinning is considered most essential.

3.28 What should be the mounting density of bivoltine silkworms?

Bamboo mountage with 1/4 square inch holes in the back side mat is better than the conventional chandrike for cocooning of bivoltine silkworms. The ripe worms must be mounted at the rate of 1,000 worms per 4' × 6' chandrike.

3.29 When to harvest bivoltine cocoons?

Spinning of cocoons is completed in 2-3 days and pupation completes on 5th day. The bivoltine cocoons, should therefore be marketed on 6th day from the spinning date. On this day pupae is hard, cocoon shell is dry and suits to long distance transportation for marketing.

4. Diseases and Pests

4.1 How to protect the larvae from diseases?

Diseases are normally the outcome of a few factors

a) existance of the disease causing organism
b) health of the worm
c) maintenance of hygiene during the rearing

To eliminate the first after the completion and before the commencement of each rearing the rearing rooms and rearing quipment should be thoroughly cleaned, washed and disenfected. No room for complacence should be left in the matter.

4.2 Is there any medicine which can be used to control some of the diseases?

In addition to all the above as a precaution against grasserie and muscardine use of Resham Keet Oushad in the following manner is suggested:

Schedule of Resham Keet Oushadh Application (in grams)		
Dusting frequency	Cross-breed	Bivoltine
After 1st moult	50	55
After 2nd moult	90	105
After 3rd moult	225	300
After 4th moult	630	840
4th day of Vth instar	1,620	2,160
	2,595	3,440

4.3 How to protect the larvae from uzifly attack?

Uzifly is a relatively new problem. If your area is new free of uzi infestation avoid brushing cocoons from uzi infested area. Uzi maggots generally get transported through cocoons. If uzifly is already existing, rear silkworms under nylon net cover or get the doors and windows of the rearing room fitted with fly proof net.

5. Planning and Management

5.1 What about planning & Management?

Sericulture being a multi-disciplinary process involving growth to mulberry and silkworm rearing, proper planning is required including preparation of a full calendar of operations both for the field as well as for the rearing. A few points particularly required to be looked into before the start of the rearing are:

Schedule of Uzicide Application			
Age Age	Bed area in sq.ft.	Trays No. (3.5' dia.)	Qty. of uzicide to be used (in ltrs.)
III instar 2nd day	90	10	0.7
IV instar 2nd day	100	20	1.4
V instar 2nd day	270	30	2.1
4th day	360	40	2.8

4.4 Should anything else be done?

In addition to above, uzicide spray to ki the uzi eggs laid on the body of the silk worm is suggested as per the followin schedule:

a) AVAILABILITY OF MULBERRY LEAF OF PROPER QUALITY IN SUFFICIENT QUANTITY

No. of dfls. to be brushed should be adjusted to the leaf growth so that there is no leaf shortage during rearing as it is not safe to borrow leaf from others which may of different quality and affect the crop adversely. No leaf should remain unutilised also.

b) AVAILABILITY OF REARING SPACE AND EQUIPMENT

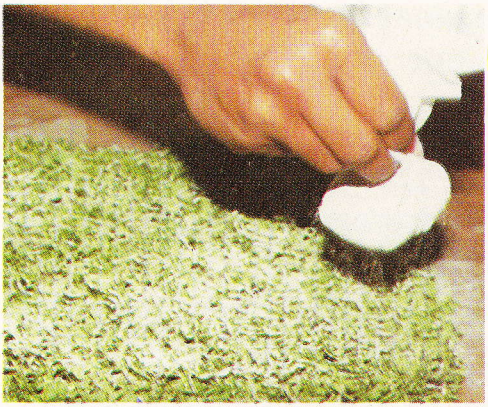
Before the start of the rearing requirement of space as well as rearing equipment should be properly assessed as crowded rearing affects the health of the silkworm and it is not safe to borrow rearing equipment from others which may lead to contamination.

c) AVAILABILITY OF MANPOWER

Sericulture is labour intensive. In addition, rearing requires some experienced persons. Arrangement for sufficient and suitable manpower should be made before the start of the rearing itself.

d) RESHAM KEET OUSHAD (RKO) & UZICIDE

Resham Keet Oushad & Uzicide should be procured and used as prophylactics instead of trying to procure them after the disease has set in or in the pest attack has taken place.



6. Reeling

6.1 What is the correct procedure to dry bivoltine cocoons?

Hot air drying method is ideal for drying bivoltine cocoons and is carried out in specially designed chambers with two objectives:

a) *to kill the pupae inside the cocoon*

b) *to dry partially or fully the cocoon and dead pupa.*

This method results in silk with superior technological qualities.

The recovery of silk is more in hot air dried batches.

There are two types of hot air drying units:

a) Shelf type (convenient for small reeling establishments)

b) Conveyor type (suitable only for big filatures)

Temperatures maintained in the shelf type are 100°C for 2 hrs. 80°C for 2 hrs. reduced to 65°C in the next two hours. Temperature maintained in conveyor type of dryer are 93 to 95°C in chamber-1, 83-85°C in chamber-2, 80-82°C in chamber-3, 77-80°C in chamber-4, 74-75°C

in chamber-5, 60-65°C in chamber-6, 55-60°C in chamber-7 and 50-55°C in chamber-8. The processing capacity is about 8,000 kg of green co-coons per day per unit.

6.2 Which method is ideal for cooking bivoltine cocoons?

There are two methods by which the bivoltine cocoons could be cooked during which process the sericin content of filament gets softened. They are:

a) **3 pan cooking**

b) **Conveyor type pressurised cooking**

3 pan cooking:

Ideal for float reeling. Three large sized basins are fitted to a common platform and filled with water and temperature maintained at 90-95°C in 1st and 3rd chambers, 60-65°C in middle chamber. Cocoons are immensed 60 records in first chamber, 30-40 seconds in 2nd chamber and 1-2 minutes in 3rd chamber. Lateron, cooked cocoons are transferred to the reeling basins (40-45°C — Reeling water temperature) , is cheap, improves reeling efficiency and cooking time is short.

Conveyor type cooking:

Ideal for sunkan reeling. Machines are available for sunkan type with pressurised type and conveyor type. The former is suitable for small establishments and the latter for bigger reeling units. In pressurised system 6 kg of cocoons could b cooked at a time. In conveyor type cookin the degree of cooking is uniform in a cocoons, in all layers, improvement reelability and silk output and bette cohesion of raw silk are note-worthy.

The pressurised cooking system is exper sive. The minifilatures and reelers havin 10 basis can have "fixed round type" pressurised cocoon boiling machine, whic is within the reach of the reelers. Th type of machine can also be manufacture locally.

Water of all reeling places, should b tested and it is unsuitable for reelin action is to be taken to correct the sam by using water softners or requirin agents.

Cooking degree should be at least 90%.

6.3 How to brush bivoltine cocoons prior to reeling process?

Mechanical brushing is preferable for bivo tine cooking. The mechanical brushing un is to be suitable attached to the reelin basins. The brushing device consists of number of small brushes made up of padd straw. The brushing is worked by a separat motor. When brushing device is lowere for operation, it gets in contact wit cocoons immersed in water at 85°C tem erature. The cocoons are thorough brushed and lifted into a adjacent bas true ends of cocoons are collected.

6.4 How to reel bivoltine cocoons?

Bivoltine cocoons should be reeled on multi-end reeling machines or automatic reeling machines to get better quality silk. Bivoltine cocoons should not be reeled on charkha. Reeling of bivoltine cocoons is to be conducted at low temperature (40-45°C), slow speed reeling, maintenance of about 10-12 ends/reeling basin is ideal from management point of view. Denier control device is preferable during reeling to get international grade silk.

6.5 Is it necessary to re-reel the bivoltine raw silk?

In cottage basin, multi-end machine and semi-automatic/automatic reeling machine the raw silk is reeled on small reels (70 cm circumference), should be re-wound to a large reel (150 cm circumference) to be uniform in width, weight (70 gms to 140 gms) and length to form a skein or bank. The re-reeling facilities Dimond cross winding and make the skein free from being gummed and entangled.

6.6 Are data available on the reeling performance of bivoltine cocoons?

Yes, there are data in this respect. The following data are from the semi-automatic reeling machine reeled at CSRTI, Mysore (mass reeling of 15-20 kg cocoons/lot):

Race	Average filament length	Average filament size (D)	Renditta	Cooking to reeling waste %	Average size (D)	Maximum size deviation	Winding breaks for 40 skeins/hr.	Neatness (%)
NB18 x NB7	1,076	2.76	7.8	20.2	20.1	1.6	48	92.5
NB7 x NB18	934	2.90	8.0	20.0	19.8	1.5	48	90.0
NB4D2	801	2.69	8.5	19.5	20.1	1.8	67	96.0
NB18	959	2.81	7.7	21.3	19.9	1.8	108	76.7
NB7	1,001	2.51	7.3	20.2	20.6	1.8	27	75.0

6.7 Are commercial reeling data of bivoltine cocoons vis-a-vis cross-breed cocoons available?

Yes, they are available and presented below. The Karnataka Silk Industries Corporation has been reeling bivoltine cocoons at the Government Silk Filatures. The following datas is for the year 1984-85:

	Semi-automatic	Automatic
Cocoons used (tonnes)	122.149	23.6
Silk obtained (tonnes)	13.029	2.7
Renditta	9.37	8.62
Kakame cost	534.36	484.99

The Karnataka Silk Industries Corporatio has given data in respect of bivoltine. an multivoltine cocoons based on their mas reeling performance and data is summa rised below:

KSIC DATA

	Bivoltine	Multivoltin
1. Cohesion (strokes)	90-140	60-70
2. Elongation (%)	19-23	17-21
3. Tenacity	3.0 to 3.3	—
4. Evenness (%)	82-88	75-85
5. Degunny (%)	24-29	22-27

Besides, for the same year, KSIC data respect of semi-automatic and automa reeling machine is also noteworthy:

Variety	Quantity of cocoons (tonnes)	Average rate/kg. (Rs.)	Silk got (tonnes)	Renditta (kg.)	Kakame cost
Bivoltine	52.9	52.33	5.9	8.9	465.85
Cross-breed	162.3	48.17	15.5	10.5	504.79
	215.2	49.19	21.4	10.04	493.96

REFERENCES

1.	Krishnaswami S	Mulberry cultivation in South India (Bulletin No. 1, CSRTI, Mysore)
2.	Krishnaswami S	Improved method of rearing young age (chawki) silkworms (Bulletin No. 3, CSRTI, Mysore)
3.	Krishnaswami S	New technology of silkworm rearing (Bulletin No. 2, CSRTI, Mysore)
4.	Jolly M S	Prospects of sericulture in coffee and tea plantations (Handout, CSRTI, Mysore)
5.	Jolly M S	Economics of sericulture under irrigated conditions (Sericulture Project-2), CSRTI, Mysore
6.	Narasimhanna M N N M Kannyadi Dr C Ravi Kumar & H K Basavaraju	Sericulture practices for Hilly Areas of South India (Booklet of National Silkworm Seed Project)
7.	Jolly M S	Appropriate Sericulture Techniques (Book, CSRTI, Mysore)
8.	Dr C Ravikumar	Western ghats as a prospective region for bivoltine — (Indian Silk, Jan. 1988)
9.	Narasimhanna M N	Yes Bivoltine: Handout of National Silkworm Seed Project, 1987

Do	Don't

1. MULBERRY:

1.1. VARIETY:

Choose the correct variety like K-2 or S-54 for plantation which can yield better quality leaves in larger quantity.

Don't go for local variety yielding less quantity of leaves.

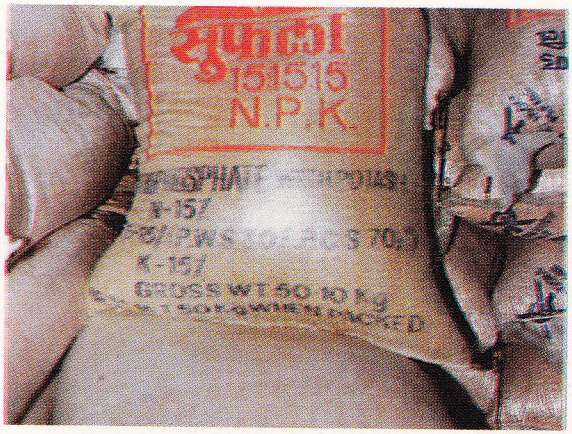
1.2. PLANTING:

Don't go for strip or other closer system of planting yielding poorer quality of leaves.

Give proper spacing (2′ × 2′) during planting for better growth of plants and production of larger quantity of quality leaves. In high rainfall and hilly regions give a spacing of 3′ × 3′.

1.3. FERTILIZATION OF THE FIELD:

1.3.1. Kind of fertilizer:



For fertilization of the field use a combination of inorganic (mineral) and organic (FYM/Tanksilt) fertilizers which can provide all the essential elements required for the healthy growth of the plants as well as silkworms.

Don't use only mineral fertilizers which cannot provide much of the trace elements required for the healthy growth of plants and silkworms.

1.3.2. Quantity:

Fertilize the field with recommended dose of manures and fertilizers, *viz.*, 20 tons of FYM, 280 kg of Nitrogen, 120 kg of Phosphorus and 120 kg of Potash per hectare per year which will give deep green mature leaves fit for bivoltine rearing. This is for the 2′ × 2′ plantation in the plains.

For hilly areas with a plantation distance of 3′ × 3′ the recommended dose of fertilization is 20 tons of FYM, 250 kg of Nitrogen, 100 kg of Phosphorus and 100 kg of Potash.

Don't be taken-away by leaf growth only. Tons of pale non-nutritious leaves could result in weak larvae and frequent crop failures with no cocoons.

Please note this is the single largest factor that determines the crop success.

1.4. LEAF HARVEST:

Don't harvest by repeated shoot cutting which gives immature leaves unfit for bivoltine rearing. Avoid leaf harvest during noon time.

Harvest leaves by plucking with one or two prunings a year depending upon the plant growth. Harvest preferably during evening and morning.

1.5. LEAF PRESERVATION:

Collect leaves in wet gunny bags or baskets and preserve them in a cool & moist place, if necessary, covered with a wet cloth to keep them fresh.

Don't expose the leaves to hot and dry conditions.

2. REARING:

2.1. REARING CLIMATE:

Select cooler areas and seasons for better bivoltine rearing. Manipulate the temperature and humidity of the rearing room to obtain the ideal climate for different stages of rearing which are as follows:

Stage	Required Temperature	Required Humidity
I	25°C	85 to 90%
II		
III	26°C	80%
IV	24-25°C	75%
V	23-24°C	85 to 90%
I	25°C	70%

Avoid rearing bivoltine in areas/seasons where/when the maximum temperature and relative humidity go beyond 30°C & 80% respectively and it is not possible to obtain the required climate even though manipulations.

2.2 REARING ROOM:

Choose cooler well ventilated room for bivoltine rearing.

Avoid rearing bivoltines in hot and badly ventilated rooms.

2.3. PLANNING:

Pre-plan the rearing assessing the availability of leaf, rearing place, rearing equipment and manpower.

Don't start the rearing without arranging for adequate quantity of leaves, rearing space, rearing equipment and manpower.

2.4. COLLECTION OF CHAWKI REARED WORMS/ SILKWORM EGGS:

Collect chawki reared worms/eggs from authorized agencies.

Don't collect eggs when chawki reared worms are available.

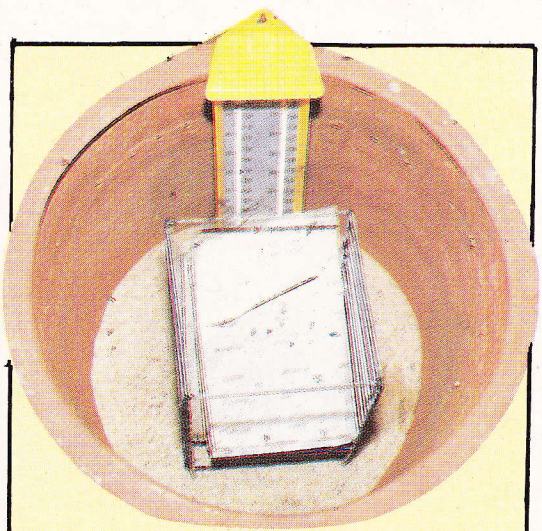
Don't collect chawki reared worms eggs from un-authorized sources.

2.5. TRANSPORTATION OF CHAWKI REARED WORMS/ SILKWORM EGGS:

Transport chawki reared worms/ silkworm eggs during cooler hours preferably during night.

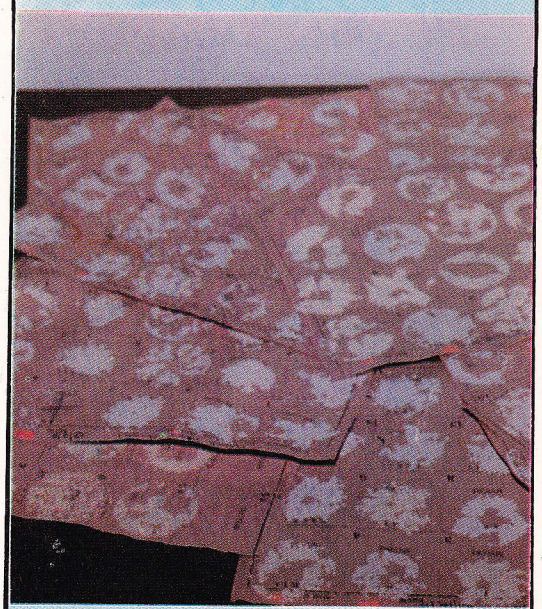
Don't transport chawki reared worms/ silkworm eggs during hotter hours.

2.6 INCUBATION OF EGGS:



Incubate eggs maintaining proper temperature (25°C) & humidity (80%) in covered pots/trays.

Don't just keep the eggs on the tray or hanging for incubation.



2.7. FEEDING:

Feed the worms four times a day with the required quantity of leaves. Feed with chopped leaves and resort to covered rearing during early (1st to 3rd) stages. This will help maintaining better humidity in the bed and provide better feeding conditions.

Don't under-feed or over-feed them both of which are bad.

2.8. LEAF QUALITY:

Always use leaves of proper quality suitable for each stage *viz.*, tender for the first two stages, medium for the next two stages and mature ones for the fifth stage.

Don't use coarse leaves for younger stages and tender ones for later stages.

2.9. BED CLEANING:

Do regular bed cleaning. Use nets of appropriate meshes for bed cleaning at different stages.

Don't allow old leaves and litters to accumulate in the beds. Avoid bed cleaning by hand and handling of worms.

2.10. BED DRYING:

Spread out the leaf and allow bed drying about half an hour before each feeding particularly when the rearing is in progress with paraffin paper covering.

Don't allow excessive humidity to build up in the bed.

2.11. SPACING:

Maintain proper spacing in the rearing bed during all the stages. In the final stage providing 480 sq.ft (24 sq.ft x 20 trays or 9 sq.ft x 56 trays) for about 40,000 worms (100 dfls).

Avoid crowded rearing leading to poorer quality of cocoons and higher mortality.

2.12. MOULTING:

Allow the worms to settle for moult and resume feeding uniformly.

Avoid stopping feeding early and resuming feeding late which make the worms weak.

2.13. CONTROL OF DISEASES & PESTS:

2.13.1. Disinfection:

Disinfect the rearing room and all the rearing implements with formaline 2% or bleaching powder 5% solution once after rearing and again before rearing. Use lime liberally keeping a tray with lime in the lowest rung of the rearing stand and spreading the same around the rearing stand and inside & outside the rearing house particularly during the rainy season. This will bring down the humidity as also prevent cross infection.

Don't start/conduct rearing without full disinfection of the rearing house and all the rearing implements. Also maintain strict hygenic condition during rearing.

2.13.2. USE OF RESHAMKEET OUSHADH:

Don't wait for use of Reshamkeet Oushadh after the disease symptom appears.

Dust Reshamkeet Oushadh on the silkworms after each moult half an hour before the resumption of feeding as a routine measure.

2.13.3. PROTECTION FROM UZIFLY:

Don't allow the worms to be exposed in any way to uzi infestation.

Don't allow uzi maggots to fall on the floor and pupate in the Corners and Crevices. This helps in their multiplication.

Use nylon nets as well as uzicide to prevent uzi infestation.

Mount uzi infested larvae (normally maturing early) separately and dry them to prevent the spread of uzi infestation.

3. MOUNTING:

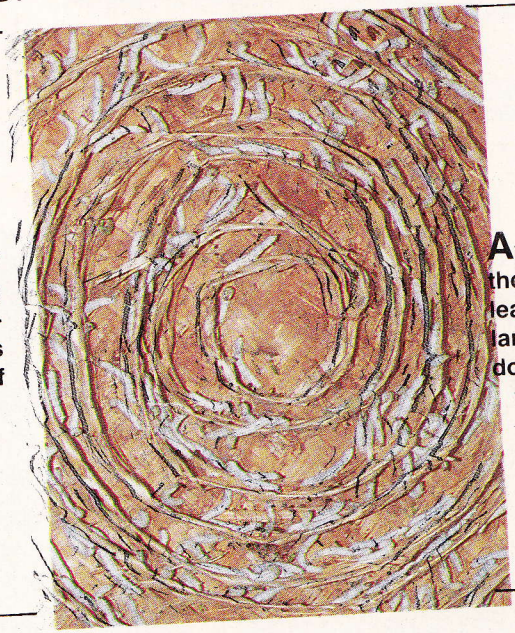
3.1. PICKING OF WORMS:

Learn to identify properly the mature bivoltine worms. Pick-up mature worms early and complete the mounting within 8 hours.

Don't delay in picking the worms which leads to the wastage of silk.

3.2. DENSITY OF MOUNTING:

Mount right quantity of worms on a spinning tray (chandrika) approximately 800 worms in one chandrika of 6′ × 4′ size.



Avoid overcrowding in the spinning tray which lead to the formation of larger quantity of double cocoons.

3.3. PLACING OF SPINNING TRAYS:

Place the spinning trays (chandrikas) in a well ventilated place/room. Heat up the room to 25-26°C if the temperature is low.

Avoid keeping the spinning trays in the rearing so long worms are there.

3.4. HARVEST OF COCOONS:

Harvest the cocoons only when they are fully formed at least five days after mounting.

Avoid earlier harvest which might lead both to poorer quality of cocoons and higher pupal mortality.

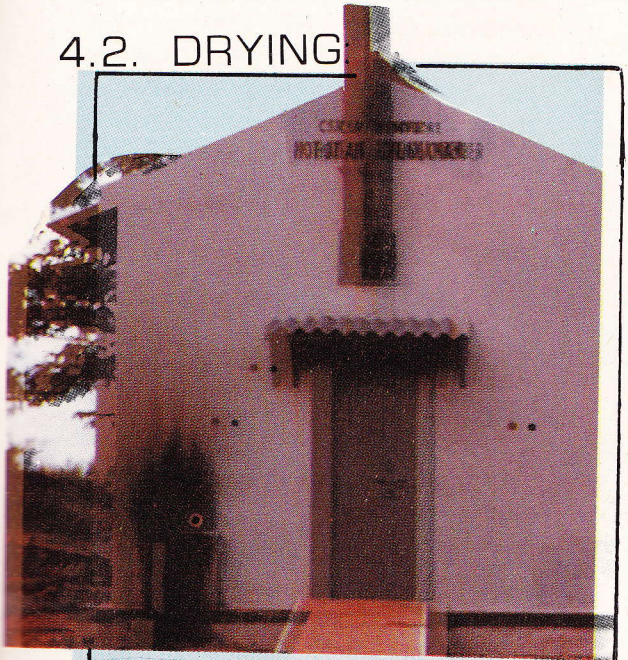
4. REELING:

4.1. DEFLOSSING:

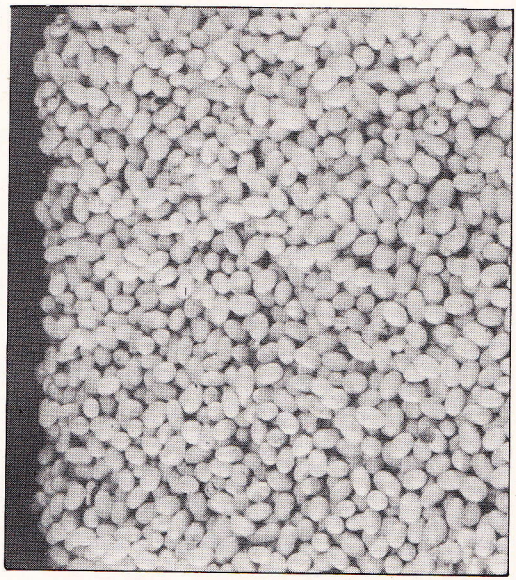
Defloss cocoons before marketing.

Don't market cocoons with floss as cocoons with floss may not reveal the true nature of cocoons and fetch lower price.

4.2. DRYING:



When you have to dry cocoons, dry through hot air stitling.



Never dry cocoons in the sun. Avoid even steam stifling. Better and more silk can be obtained from hot-air dried cocoons.

4.3. SORTING:

Sort cocoons before reeling. Adopt appropriate type of cooking and reeling method for each type of cocoons.

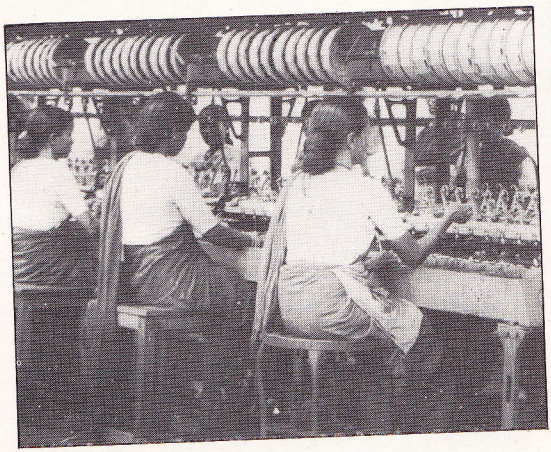
Don't cook and reel cocoons without sorting which may increase renditta and produce poor quality of silk.

4.4. BRUSHING:

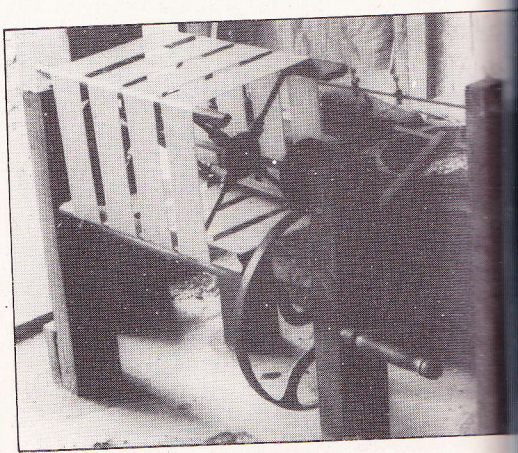
Resort to collective mechanical brushing which can save labour and brush cocoons uniformly.

Avoid hand brushing which is time consuming and does not give unirom results.

4.5. REELING:

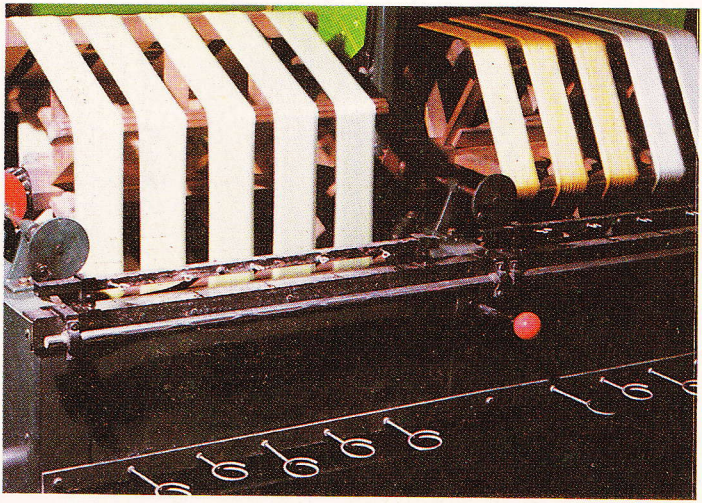


Reel bivoltine cocoons in cottage basin, multiend basin or semi-automatic machines according to the quality.



Don't reel bivoltine cocoons on charkha which cannot produce good quality of raw silk.

RE-REELING:



Re-reel raw silk on standard re-reeling machines with drying arrangements to avoid gum spots & reduction in winding breaks. Re-reeled silk always fetches higher price. Also do proper laching and skeining to avoid entanglement.

Do not market silk without re-reeling, proper laching and skeining.

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