

# MANUAL ON YOUNG SILKWORM REARING



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JICA BIVOLTINE SERICULTURE TECHNOLOGY DEVELOPMENT PROJECT  
CENTRAL SERICULTURAL RESEARCH AND TRAINING INSTITUTE  
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## PREFACE

*Japanese scientists are guiding Indian scientists of Central Silk Board since 1991 under the Japan International Co-operation Agency (JICA) aided Bivoltine Sericulture Technology Development Project (BSTDP) in six major fields of sericulture, viz. Mulberry Breeding and Cultivation, Silkworm Breeding, Silkworm Rearing, Silkworm Disease Control, Seed Production Technology and Silk Reeling. In Silkworm Rearing two long term experts and three short term experts worked in Rearing Technology Laboratory and helped in developing rearing technology for bivoltine sericulture. Four scientists from Rearing Technology Laboratory were also trained in Japan. This manual is the outcome of the studies conducted in Rearing Technology and Innovation Laboratory of the CSRTI, Mysore during the project period.*

*The young silkworm rearing is a very important aspect of sericulture industry. Successful young silkworm rearing depends upon the perfect understanding of nutritional and environmental conditions. Failure of silkworm crop is often traced to bad management and rearing of young silkworms. This aspect is therefore more important in the case of bivoltine silkworm rearing. Although enough information are available elsewhere on young silkworm rearing an indepth study on the practical aspect of commercial chawki rearing in Indian conditions with a focus on the nutritional aspect has become essential. This manual provides relevant information with updated technology of practical utility with regard to various chawki rearing operations.*

*This manual will serve as a hand book to the technical personnel dealing with the co-operative chawki rearing centres to achieve full potentiality of young silkworm rearing in tropical conditions. We are grateful to Dr. Y. Ohtsuki, JICA Team Leader, for his guidance and suggestions. We are thankful to Dr. T. Inokuchi, Dr. M. Miki and Dr. Kuribayashi, JICA Experts for their valuable contributions in bringing out this manual. We acknowledge the assistance extended by the scientists in Rearing Technology Laboratory. We are also grateful to Japan International Co-operation Agency (JICA) for making this study possible through the BSTD project.*

**R. K. Rajan**  
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# INTRODUCTION

The young age silkworm rearing or chawki rearing is a vital aspect of sericulture industry for the development of healthy larvae and harvesting of successful cocoon crop. After purchasing the silkworm eggs, it is better to incubate and rear young silkworms upto second moult in a chawki rearing centre under the guidance of a skilled technician providing nutritious leaves and optimum environmental conditions.

In developed countries like Japan, China and Korea, about 95% of the farmers receive chawki reared larvae (young age silkworms) whereas in India it is only 10 -15% at the most. In India where the situation is more heterogenous with regard to rearing facilities, environmental conditions and cultivation practices, chawki rearing is a must to reduce the crop loss and increase the cocoon yield. The advantages of co-operative chawki rearing of young silkworms are many. Some of them are :

- a. Stabilization of cocoon crop and increase in yield.
- b. Improvement in quality of cocoons.
- c. Control over disease spread.
- d. Reduction in rearing expenditure and
- e. Distribution of labour for other works.

The important aspects of young silkworm rearing management are a suitable separate rearing house or room, well maintained mulberry garden with assured irrigation facility and adequate agro inputs besides well trained manpower at workers and managerial level. Care for silkworms starts from the stage of procurement of silkworm eggs from the grainages itself. All these aspects of young age rearing are dealt in different chapters of the manual critically in order to ensure best result with regard to crop stabilization and improvement in cocoon yield.

## Handling of Silkworm Eggs

Silkworm eggs are distributed to the farmers for commercial rearing when active development of embryo is in progress. In fact, silkworm eggs are supplied to the farmers on 3rd to 5th day of oviposition in case of multivoltine and acid treated bivoltine eggs or after the termination of hibernation in bivoltine eggs. Transportation of eggs during the later stage of development affect the hatchability and ultimately the health of the larvae and the cocoon crop. During transportation of eggs, the following precautions should be taken by avoiding

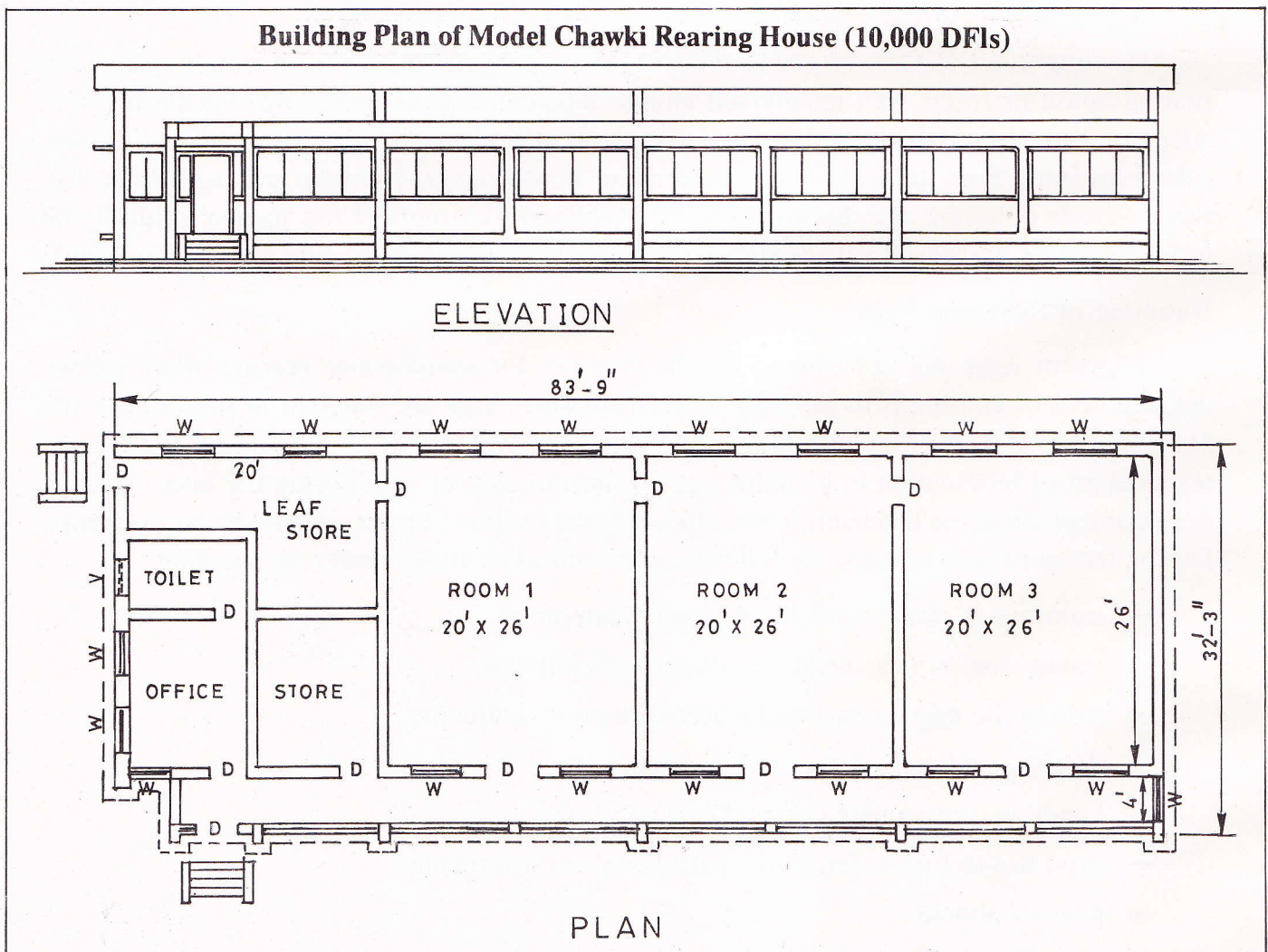
- exposure to direct sunlight and high temperature.
- transportation in sealed box without perforations.
- storing the eggs in enclosed places with poor ventilation.
- direct or indirect contact with tobacco.
- handling contaminated with pathogens.
- exposure to fumes, fertilisers, petroleum and insecticides.
- physical shocks.

Silkworm eggs should be transported from the grainages during the cooler hours of the day and specially designed egg transportation bags designed by CSRTI, Mysore could be used for the purpose (Fig. 1). These bags are specially designed to maintain high humidity and reduce the temperature by wetting the surface. The bag has got a capacity to transport 400 Dfls of sheet eggs. As far as possible eggs should be incubated in the grainage and eggs should be supplied during eye spot stage i.e., two days prior to hatching and kept in a black paper cover.

### Rearing House for Chawki Rearing

It is desirable to have separate rearing house or room for young silkworms preferably with RCC roofing and provided with good ventilation (Fig. 2). If the rearing house is too big, it is difficult to maintain optimum temperature and humidity. Young age rearing house or room can also be used as an incubation room for silkworm eggs.

The building structure should be such that fluctuations in external environmental conditions should not affect the inside condition and thus the inner climate can be regulated. It would be convenient for this purpose that the house is built with thick walls or double wall with air pocket inside or with hollow bricks. Providing false ceiling and ventilators also help in regulating environmental conditions. Rearing house must be partitioned into several rooms in order to make it convenient for rearing and maintaining the temperature and humidity.





**Fig. 1** - Egg transportation bag

**Fig. 2** - Model chawki rearing house

A model for rearing 10,000 Dfls at a time upto second moult is given and equipment required in Annex.1. A building of size of 85' x 33' is proposed. Instead of one big hall, three separate rooms are proposed for the purpose of maintaining temperature and humidity. Each room in the model can accomodate seven chawki stands with sufficient working space. 3500 Dfls can be reared upto second moult in each room.

### Disinfection of Rearing House and Equipments

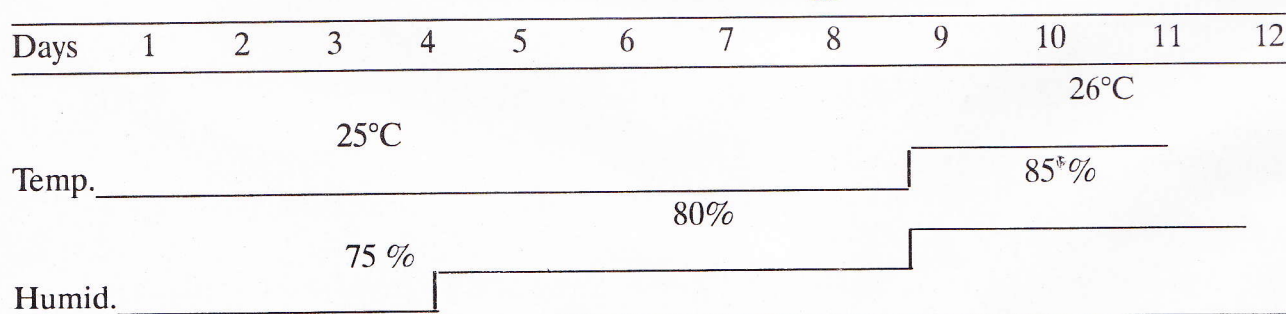
Before receiving the silkworm eggs, the rearing house and rearing equipments must be cleaned thoroughly and washed in 5% bleaching powder solution. Following this rearing equipments are arranged inside the rearing house, doors and windows are closed airtight and 2% formalin is sprayed using a power sprayer. The temperature of the room should be above 25°C. To disinfect 100 sq.ft. of space with equipments about 1500 ml of 2% formalin (81 ml of commercial formalin) is required. After spraying, rearing house should be closed for 24 hrs. and opened only next morning. Before incubation, the rearing room and rearing equipment must be made completely pathogen free. It is also necessary that proper hygienic conditions are maintained inside the rearing house during incubation and rearing.

### Incubation of Silkworm Eggs

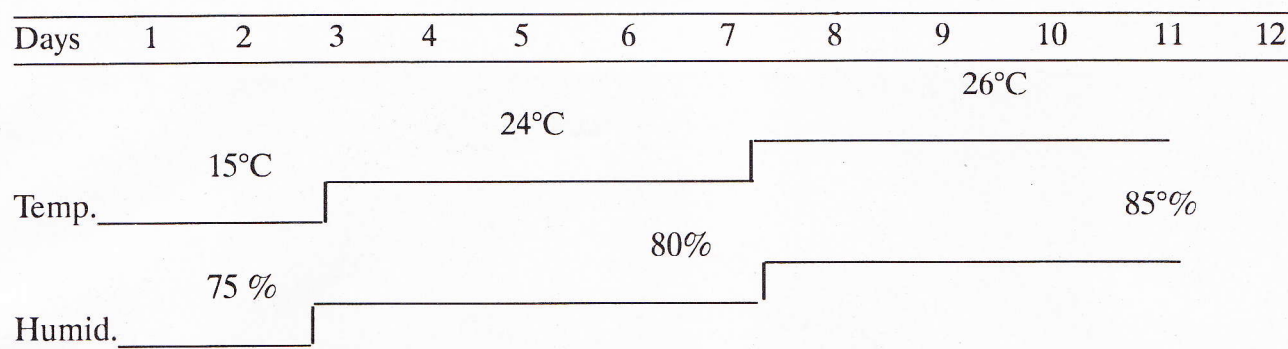
Silkworm eggs after receiving from grainages must be surface sterilized by dipping in 2% formalin solution for about 10 minutes and dried in shade before incubation. Conditions of incubation affect the hatchability and viability of silkworms. Incubation of eggs aim at uniform development and ensure uniform hatching. The incubation temperature and humidity requirement are different for acid treated bivoltine eggs and hibernated bivoltine eggs. Incubation of silkworm eggs should be done in a room having temperature of 25°C, relative humidity 80% , air current of 0.3m per sec. and photoperiod 16 hrs. light (15-20 lux) per day. In the incubation room it is desirable that the temperature and humidity are kept at optimum level to the best of ability especially in the later period of incubation. If the humidity in the incubation room is less it will lead to mortality of eggs, poor hatching and weak larvae. Incubation has a profound influence on the voltinism, larval health and on the yield and quality of cocoon crop.

The following chart indicates the temperature and humidity requirement during incubation.

Table 1  
Acid Treated Bivoltine Eggs



## Hibernated Bivoltine Eggs



During incubation, eggs should be spread in a single layer to provide uniform humidity and temperature. Eggs incubated as above hatch in 10 -11 days after incubation has started. Two days before hatching, the colour of the eggs changes into a lighter shade with a blue point. This is the head pigmentation stage. The next day the egg colour changes into blue and is called as the body pigmentation stage. These two stages are very sensitive to low humidity.

### Black Boxing

If the eggs in the body pigmentation stage are transferred to dark room, the hatching of the eggs can be inhibited to certain extent and the growth of embryo which are late can be accelerated. This process is called black boxing of eggs. The uniform hatching of all the eggs can be made possible only when these eggs are exposed to light after black boxing. Black boxing is done by covering the silkworm eggs in black paper or black cloth. To avoid the escape of newly hatched larvae from the egg sheet, the eggs must be wrapped in a tissue paper during the body pigmentation stage. Farmers should be given a black bag containing pigmented eggs from the grainages instead of distributing eggs in early stages.

### Postponing of Hatching

If hatching of incubated eggs has to be postponed, the following measures are to be taken.

1. One day after incubation - eggs are to be kept at 5°C for postponing hatching for a period of 10 days.
2. More than two days passed after incubation started - incubation should be continued till the body pigmentation stage and afterwards they can be preserved at 5°C for a period of 3 days without any damage to the physiology of embryo.

### Brushing of Silkworm Larvae

The process of transferring of newly hatched larvae (Fig. 4) from egg sheet to rearing seat is called brushing. For this either a soft camel brush or feather is employed. On the expected day of hatching the eggs are exposed to light at 8.00 a.m. Good hatching can be obtained by 10.00 a.m. This is the ideal time for brushing. Delayed brushing should be avoided. If hatching is irregular, take two days brushing separately in time. Newly hatched larvae can also be refrigerated at 10°C and 80% humidity and uniform brushing can be taken up.

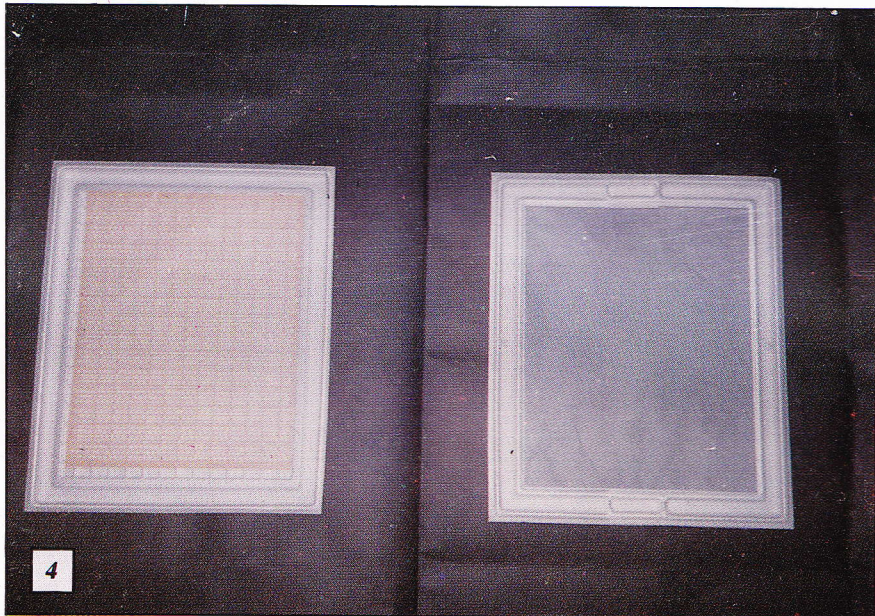


Fig. 3 - Loose Egg Boxes

Fig. 4 - Loose Eggs Incubation Box

## **Brushing Methods**

Brushing method depend on the type of egg production method, i.e., sheet eggs or loose eggs.

### **Brushing of Sheet Eggs**

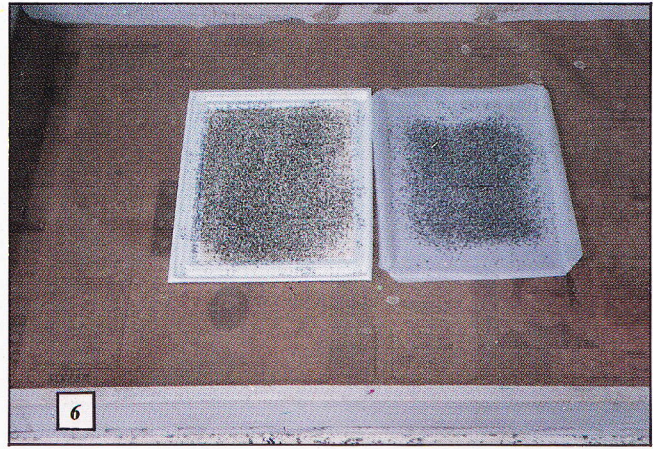
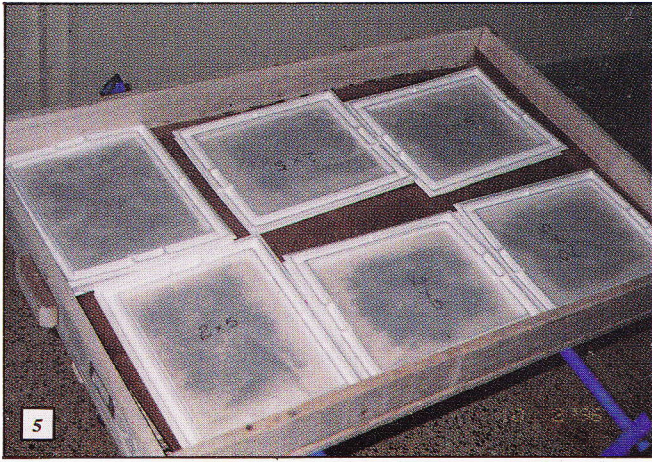
On the day of hatching, the egg sheets should be removed from black boxing, wrapping paper is opened and spread uniformly in one layer on a tray with paraffin paper as seat. After one or two hours of exposure to light when hatching is obtained, the egg sheet with tray is removed from light source and chopped mulberry leaves of size 0.5 cm. sq. are sprinkled on the newly hatched larvae on the egg sheet. After about 30 minutes when all the larvae gather on the leaves they are transferred to the rearing seat giving suitable spacing, and the first feeding is given to the larvae. The rearing bed is covered with another sheet of paraffin paper to complete the operation of brushing. Avoid direct tapping of worms or direct brushing of larvae to rearing bed. Use chop stick for spreading the rearing bed or making rearing bed.

### **Incubation and Brushing of Loose eggs**

Loose eggs comes in egg cases of 50 Dfls and is about 20,000 eggs in each (Fig. 3). At the time of incubation and black boxing the loose eggs are transferred into a bigger incubation case and preserved in one layer till the day of hatching (Fig. 4). Above the loose eggs a mosquito net of appropriate size is spread and is again covered by a tissue paper. On the day of hatching when the eggs are exposed to light the eggs hatch and the hairy worms move out through the mosquito net and get attached to the upper most tissue paper covering (Fig. 5). At the time of brushing the tissue paper covering is carefully removed and put on the rearing bed keeping the side bearing the worms up, while the incubation case with the mosquito net is put along with (Fig. 6). When all the worms are hatched, chopped leaves are sprinkled on the tissue paper and the mosquito net (Fig. 7). Cover the incubation case with a paraffin paper and keep undisturbed for one hour after which the worms along with the mosquito cloth is transferred into the rearing tray and the worms on the tissue paper are brushed using a feather. During the second feeding sufficient bed spacing is given and rearing is continued.

### **Characteristics of Young Silkworms**

The rearing of first two instars of silkworm form the young age rearing (Fig. 8 a & b). But the third instar is also more close to the young age in its nutritional and environmental requirements. Therefore, young age rearing represents growing of larvae upto second or third moult. The success of young age rearing technology depends on the perfect understanding of the requirements of silkworms, manipulation of their nutritional and environmental conditions to obtain maximum growth and robustness. Young silkworm need more care and attention as their resistance to disease is low. But they are resistant to high temperature, high humidity and bad ventilation. Cool and low humid conditions are bad for the larvae throughout the growing stage as these conditions injure health of the larvae and lead to lower cocoon quality. Effect of pesticides, chemicals and gases are more injurious during the first instar. Of the total leaf requirement only 6.33 % is utilised during early three instars, but the larvae grows 400 times



**Fig. 5** - Newly hatched larvae after exposure to light

**Fig. 7** - First feeding for newly hatched larvae

**Fig. 6** - Newly hatched larvae

**Fig. 8** - a) 1st instar larvae  
b) 2nd instar larvae

in body weight and 300 times in body size, during this period. Thus maintenance of the quality of nutrient leaf supply from the brushing till the end of third stage becomes very crucial to crop success.

In newly born larvae, the body water content remains very low, but it increases rapidly till the second instar. It requires high water content in mulberry leaves (75-80%) at this initial stage. At the early instar, ingestion of mulberry leaves is slow but digestion is high. But with increase in growth ingestibility increases and digestibility decreases. The amount of ingesta and digesta per given time increases in accordance with rise in temperature. The digestibility is however, not so affected by environmental temperature; but within optimum range of temperature it increases a little with rise of temperature. The amount of ingesta and digesta is higher in the case of healthy larvae than unhealthy ones and bigger in case of soft leaves than coarse leaves. Growth rate of the first instar larvae is very fast and if nutrition is poor the larval growth gets retarded.

### **Environmental Conditions for Young Silkworms**

Environmental factors such as temperature, humidity, light and air current during rearing have a remarkable influence on the growth of the larvae and ultimately on cocoon crop quality. However these influences are not same throughout the rearing period, but varies in different stages of growth. Hence, it is necessary to provide most favourable climatic conditions suited to the silkworms at different stages.

#### **1. Temperature**

Rearing temperature can be divided into three groups in view of its effect on the physiology of silkworms.

(a) 20-28°C - temperature which is harmless to the growth of silkworms. Temperature higher or lower than the range is harmful to the physiology of silkworms and cause unhealthy growth of silkworms.

(b) 25°C - temperature which is favourable for the healthy growth of late age silkworms.

(c) 26 - 28°C - Temperature which is favourable for making good quality cocoon. 28°C for first instar, 27°C for second instar and 26°C for third instar. If silkworms are reared in such temperature it is absolutely necessary to feed them with rich nutritive leaves in sufficient quantity. If the leaf quality and quantity are insufficient, it is necessary to lower the temperature by one degree in each instar.

Regarding rearing temperature of each instar, it is better that the temperature in the former period is higher than that in the latter period. In case sufficient amount of nutritive mulberry leaves are not given to silkworm, high temperature will be harmful to the physiology of silkworm injuring the health and produce poor quality cocoons.

#### **2. Humidity**

The effect of rearing humidity upon the growth and health of silkworm is similar to that of rearing temperature. High humidity makes the length of the growing period of silkworms

short, accelerating the physiological activities whereas low humidity makes the length of the growing period longer. Humidity influences the physiological functions of silkworms directly. The amount of ingestion, digestion and metabolism increase with rise in humidity. Indirectly humidity affects the rate of drying of mulberry leaves in the rearing bed thereby its suitability as a feed and its consumption. Low humidity causes drying of mulberry leaves, reduces consumption, retarded larval growth and larvae become weak and easily susceptible to diseases. Considering the overall effect humidity range of 85% - 90% in first and second instar and 80% in third instar are ideal for young silkworm. But if the air of the rearing room is too moist it becomes favourable for the growth of pathogenic microbes and consequently silkworm suffer from diseases. During moulting period, low humidity of about 70% is preferable for the drying of the rearing bed.

### **3. Light**

Silkworms are fond of dim light of 15-30 lux and avoid strong light and darkness. Light has little influence on the health and survivability of silkworms, but it influences the distribution of larvae in rearing bed. Longer photoperiod during early instars strongly affect the hibernating character in the next generation, silkworms require a minimum period of 16 hrs. light per day. In case of silkworms reared in such conditions the weight of cocoons and cocoon shell become heavier than that of the larvae reared in dark condition. It is also necessary that light is provided from upper surface of rearing bed while keeping the under surface dark, otherwise late growing of larvae and missing number of larvae increases.

### **4. Air Current**

Silkworm breath through the 18 spiracles on both sides of the body, supplying blood with oxygen through tracheae which are distributed throughout the body. Fresh air is required for silkworms. In the rearing room the air is polluted with CO<sub>2</sub> from workers and mulberry leaves, formaldehyde gas from disinfectants and ammonia from litter. The safe limit for silkworm rearing is CO<sub>2</sub> 1-2%, formalin gas 1%, SO<sub>2</sub> 0.02% and ammonia 0.1%. The young silkworms are less resistant to toxic gases. Since the production of these gases are comparatively less during early instars, it is less important to ventilate during younger stages than during later instars. However, care should be taken to remove paraffin paper cover and keep rearing bed open before each feeding to allow the movement of fresh air. It should be remembered that high moisture in the bed helps harbouring of fungus and other pathogens.

### **Maintenance of Environmental Conditions**

The optimum temperature and humidity required for young silkworm rearing is 26-28°C and 85-90% relative humidity. If the room temperature is below the optimum level, rearing room should be heated up by electric heater or charcoal stove especially during night time in winter season. By proper designing of the rearing house, by providing circulation of air, rearing room can be protected from the effects of high temperature outside.

Regulation of humidity for young age rearing is achieved by performing box rearing or paraffin paper rearing and providing folded wet news paper around the rearing bed. However,

use of wet foam pads are not advisable for increasing the bed humidity as they could be major source of contamination. The paraffin paper which is used as a seat and cover can be folded on all the four sides (wrap up rearing) to prevent the driage of mulberry leaves if temperature and humidity are maintained inside the rearing room. Rearing humidity above 90% is not desirable for young age rearing and during such period box rearing method and use of paraffin paper cover can be dispensed with.

Table 2  
**Requirement of Temperature and Humidity During Early Instars**

	I instar	II instar	III instar
Temperature	28°C	27°C	26°C
Humidity	85-90%	85%	80%

### Mulberry Leaves for Young Age Silkworms

Mulberry leaves are the sole food for silkworms in commercial sericulture and the quality and quantity of the mulberry leaf fed during rearing decide the success of silkworm crop. Hence choice of mulberry leaves suitable for healthy growth of silkworm is one of the most important factor in sericulture. Mulberry leaves suitable as food for silkworms must contain several chemical constituents such as water (80%), protein (27%), carbohydrate (11%), minerals and vitamins and these must have favourable physical features such as suitable tenderness, thickness, tightness etc., in order to be eaten by silkworms.



**Fig. 9** - Soft leaves for infant silkworms - rich in water content, protein, carbohydrate and minerals.

The leaves for infant silkworms must be soft and rich in water content, protein, carbohydrate and minerals (Fig. 9). To attain high level of moisture in the leaf, mulberry garden should be provided with high quality of FYM (40 tonnes) and the garden should be irrigated every 5 days from the day of pruning. Alternatively, drip irrigation or sprinkler irrigation can be arranged every day.

### **Agronomical Practices for Chawki Mulberry Garden**

Since young silkworms require specific quality leaves and such leaves are not produced from a general garden, specific packages have been developed for producing mulberry leaves of required quality for young age silkworm rearing.

The mulberry plantations should be taken up in a flat land with porous fertile sandy loamy soil. For new chawki garden V1 or S36 variety is preferred and spacing of 60 x 60 cm is ideal. After an establishment period of one year, the plants should be pruned at crown, 20 cm above ground level during onset of monsoon. After 35 days of bottom pruning harvesting of leaves is commenced for next 10 days (up to second moult). At the end of rearing the top terminal bud is to be clipped. Twenty five days after top clipping second harvesting of shootlets is to be done for rearing worms up to second moult. Thereafter plants are again pruned at crown (80th day after first pruning). This cycle has to be repeated four times to get 8 crops in a year.

The annual dose of manuring is 40 mt FYM per ha applied in two equal splits in first and fifth crop. The annual fertilizer dose worked out is 225 N:150 P:150 K Kg per ha. It is to be applied in 8 equal split doses at 28 N:19 P:19 K Kg per ha per crop. This can be applied as 127 Kg Suphala 15:15:15 + 20 Kg of Urea per crop.

3.75 ha cm of irrigation water is to be provided once in 4 - 6 days by ridges and furrow method (85000 gallons of water per ha each time). Individual leaf picking is recommended for first, third, fifth and seventh crop, while shootlet are to be harvested in second, fourth, sixth and eighth crop for the purpose of rearing. Plants can be pruned at the crown, 20 cm above ground level four times in a year after second, fourth, sixth and eighth crop matching with the training schedule. The above technology ensures a high yield of 28 mt of chawki leaves per ha as against 7 mt per ha in ordinary garden. The economics of maintaining chawki mulberry garden is given in Annexure 2.

### **Food Value of Mulberry Varieties for Young Age Silkworm Rearing**

Thirteen mulberry varieties in CSRTII germplasm were analysed for their food value for young age rearing by moulting test and larval growth after first moult. Silkworms were fed with just sufficient quantity to initiate and complete moulting. The first instar larvae is more ideal for moulting test since in the first instar 60% of the eating period represents active ingestion and digestion. In all other instars the moulting ratio is also dependent on the robustness and growth of larvae in the previous instar. The newly hatched larvae are more homogenous in all aspects than in other instars. Since the larval period and growth are linked to rearing temperature and humidity, moulting test was done under controlled conditions of temperature



**Fig. 10** - Feeding of rich nutritive leaves in sufficient quantity is absolutely necessary in young age silkworm rearing.

**Fig. 11** - Arranging of leaves for chopping manually.

**Fig. 12** - Chopping leaves by leaf chopping machine.

and humidity. The study indicated that V1 variety is best suited for young age silkworm rearing followed by S36, V4, S54 and S34 (Fig. 10). A study on the conversion efficiency of mulberry leaf to cocoon shell also indicated that V1 mulberry variety is superior to all the other mulberry varieties and is at par with superior Japanese mulberry variety Ichinose.

### **Selection of Mulberry Leaves for Young Age Silkworms**

Mulberry leaves for young silkworms must be soft and rich in water content (78-80%), protein (26-28%) and carbohydrate (11%). The top tender leaves meet these requirements. In individual leaf feeding the largest glossy leaf and 4 to 5 leaves below it contain high moisture and protein% are preferred. In case of shootlet feeding, the small lateral branches with 5 to 6 leaves are preferred.

Silkworms do not feed well on leaves withered more than 10%. The consumption by the worms changes in accordance with the moisture content in the leaves. Therefore, it is important to supply fresh leaves and arrest quick withering of leaves both while in storage and in the rearing bed. Under tropical conditions leaf drying is faster. Leaves plucked in the morning are better than those in the evening. When large quantity of leaves are required the harvested leaves should be transported immediately to the rearing house in baskets covered with polythene sheet or wet cloth.

### **Preservation of Mulberry Leaves**

Harvested leaves/shootlets must be preserved in a clean germ free area under high humidity and low temperature. For preservation of small quantity of leaves earthen pot buried in wet sand is ideal and also cheaper. For large quantity of leaves, wooden chamber covered with gunny cloth and polythene sheet can be used.

The length of the period for preservation of leaves must be limited to 12 hrs and leaves should be periodically turned to avoid fermentation and decaying of the quality. In summer sprinkling of water on the leaves and frequent wetting of the gunny cloth covering are required. Free movement of air helps to preserve the quality of leaves.

### **Feeding for Young Silkworms**

Mulberry leaves for young silkworm are to be harvested in the cool hours of the day and should be preserved in cool and wet condition to prevent them from withering. Leaves should be chopped in order that they are supplied to silkworms evenly. The size of the chopped leaves are variable according to the form of leaves and larval stage (Fig. 11)

**Table 3**  
**Size of Feeding Leaf in Early Instars**

<b>Instar</b>	<b>Chopped leaves (mm<sup>2</sup>)</b>	<b>Shootlets (mm<sup>2</sup>)</b>
Ist instar	6-12	12-24
IInd instar	12-18	13-24
IIIrd instar	18-30	entire

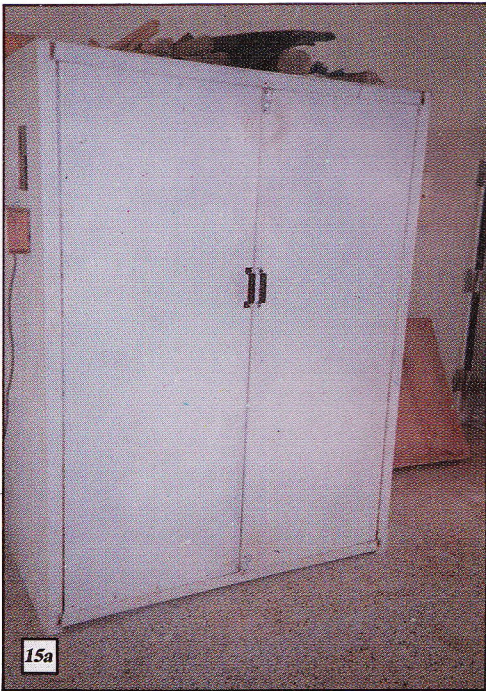
Size of the chopped leaves should be smaller in the earlier stage premoulting stage of each instar and larger at the voracious age of each instar (Fig. 12). The amount of mulberry leaves to be supplied to silkworms, the frequency of feeding etc. are variable accordingly to the rearing temperature, humidity, ventilation, spacing and form of leaves etc. In normal type of spacing at optimum temperature and humidity the amount of mulberry leaves supplied to silkworms and frequency of feeding for 10,000 larvae are as given in Table 4.

### Rearing Methods for Young Age Silkworms

There are different methods of young age silkworm rearing which are in practice. All the methods aims at preventing driage of mulberry leaves fed to the silkworms and to maintain proper temperature and humidity in the rearing bed. The most popular methods of young age rearing are box rearing, stand rearing and chamber rearing. In all the cases paraffin paper is used as both

Table 4  
Standard Rearing Schedule for Young Age Silkworms (10,000 Larvae /25 dfls)

Instar	Temp- erature	Humidity	Day	Feeding Time	Leaf Total (g)	Daily Total (g)	Instar (g)				
I	28°C	90%	1	10.00	50	200	1000				
				14.00	70						
				21.00	80						
			2	06.00	100	450					
				14.00	150						
				21.00	200						
			3	06.00	100	350					
				14.00	100						
				21.00	150						
						4		<b>Moulting</b>			
			II	27°C	85%	5		09.00	200	1000	3750
								14.00	300		
21.00	500										
6	06.00	600				1900					
	14.00	600									
	21.00	700									
7	06.00	550				850					
	14.00	300									
						8	<b>Moulting</b>				
III	26°C	80%				9	09.00	700	2900	13750	
							14.00	1000			
			21.00	1200							
			10	06.00	1350	4550					
				14.00	1500						
				21.00	1700						
			11	06.00	1500	4800					
				14.00	1500						
				21.00	1800						
			12	06.00	1500	1500					



**Fig. 13 - Box Rearing**

**Fig. 14 - Stand Rearing**

**Fig. 15 - a) Outside view of Chamber Rearing**

**b) Inside view of Chamber Rearing**

seat and cover. Wet foam pads are used all round the bed to increase the humidity. But use of foam pads without proper disinfection can lead to contamination and disease. Hence, instead of wet foam pads, use of wet folded old news paper which can be disposed of after each rearing, is more ideal when humidity is below 50%. An alternate method of rearing without using foam pads is the "Tutsumi iku"\* or wrap up rearing where in all the four sides of the rearing bed are folded with a paraffin paper. Wrap up rearing is done only during the first two instars when the humidity is in the range of 50-70% and is possible to increase the bed humidity by 20-30%. At the time of feeding, the rearing bed is kept open for 30 minutes for gaseous exchange. Wrap up rearing help in reducing the drying of chopped mulberry leaves and to maintain the bed humidity with the moisture content inside the leaf. Polythene sheet can also be used as a seat and cover in rearing bed in place of paraffin paper. Polythene sheet should not be more than 400 gauge thickness and can be used several times after disinfection. Blue polythene sheet has got a more cooling effect on the larvae compared to other colours.

### **(1) Box Rearing**

This method is practiced when temperature and humidity are lower. Wooden trays or plastic trays of 4'x 3' or 3'x 2' and 4" depth are used. During eating period trays are arranged one above the other upto a convenient height on a chawki rearing stand like a box. Arranging of the trays in this method can increase the rearing bed temperature and humidity (Fig. 13). Thirty minutes before feeding and during the moulting period paraffin paper cover and wet old news papers are removed and the trays are arranged in a criss-cross pattern for allowing the rearing bed to dry. This method is ideal for chawki rearing centres as minimum space is required for large rearing.

### **(2) Stand Rearing**

When optimum temperature and humidity are available or temperature is high in the rearing house young age rearing is done in tray on a stand like late age rearing (Fig. 14). Paraffin paper is used as seat and cover for young silkworms in a tray. Stand rearing is not suited for large scale rearing as it require more space for rearing.

### **(3) Chamber Rearing**

Chamber rearing is useful when temperature and humidity are very low. Chambers are made of plywood sheets with wooden frame of size 6'x 4'x 5' with double door and provided with heater and humidifier inside (Fig. 15 a & b). It is possible to maintain optimum temperature and humidity by providing thermostat and humidstat. Rearing is done inside the chamber by piling up the trays on a chawki stand or on a small rearing stand. Rearing is done by using paraffin paper as a seat and cover or by wrapping in paraffin paper. Maintenance of temperature and humidity is easy inside the chamber because of the restricted area. The chamber is also provided with ventilators on the upper and lower side through which aeration inside the chamber is achieved. A chamber made of above size can accomodate 300 Dfls till second moult.

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\* Japanese word to indicate wrapping of rearing bed.



Fig. 16 - Arrangement of rearing bed after feeding

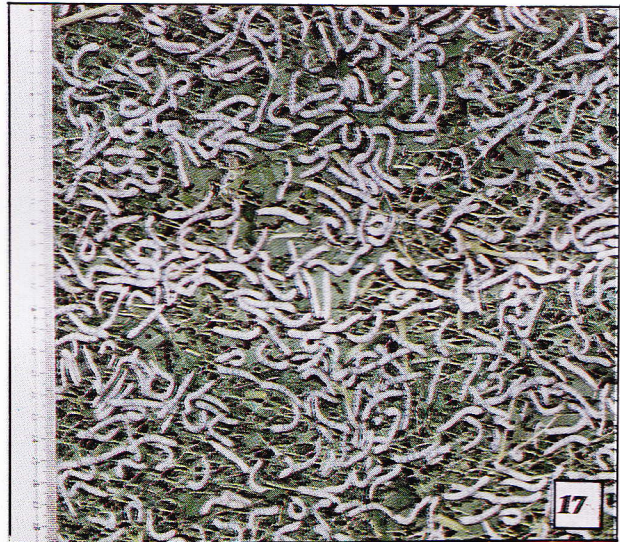


Fig. 17 - 3rd instar larvae

The paraffin paper used for covering the rearing bed should be new and of good quality without smell of petroleum and melting point of the paraffin must be above 50°C. The cover should be taken away about 30 minutes before feeding to admit fresh air and light into the box in order that larvae can crawl on the surface of the rearing bed.

During the third instar paraffin paper is applied only on the upper surface of the rearing bed and wet newspaper and other materials used for increasing humidity should be removed. It is desirable to keep some space between the upper paraffin paper and the rearing bed. If polythene sheets are used as the covering material, the space between the upper surface of the rearing bed and covering sheet must be at least 10 cms. (Fig. 16). The area of the rearing bed has an intimate relation to the amount of mulberry leaves to be supplied to the silkworms. Any shortage of amount of leaf supplied to the silkworms is unfavourable and at the same time dense rearing and too much supply of leaf must be avoided.

### Spacing

Optimum rearing bed area from brushing to the end of larval stage is important to attain full larval growth, good survival and successful cocoon crop. Young age rearing are often conducted in a crowded condition. Spacing required for 100 Dfls bivoltine silkworms (40,000 larvae) for chawki rearing is as follows.

Table 5  
Space Requirement in Early Instars

Instar	Begin sq.ft.	End sq.ft.	Larvae/sq.ft.
I	4.00	18.00	2300
II	18.00	55.00	750
III	55.00	120.00	350

### Frequency of Cleaning

Left over leaf and litter accumulated in the rearing bed contributes to increase in bed humidity and temperature causing multiplication of various pathogens. Therefore, care is taken to spread out and dry the rearing bed and also remove the litter and unfed leaf periodically. Generally, the litter cleaning is not preferred during the first instar, as it could lead to increase in missing % of larvae. Every day before the first feeding the rearing bed is extended to allow fresh air and dry the old leaf and litter. This makes the larvae crawl upon the surface of the bed. Cleaning is done twice during second instar, first on the day of resumption of feeding and the next before the worms prepare for second moult. In the third instar also two cleaning is sufficient, first after second moult, and second before settling for third moult (Fig. 17). Since the young silkworms are delicate, they are not handled directly. Cleaning is done by nylon net of mesh size one cm. sq. (1.00 cm<sup>2</sup>). Cleaning net is applied covering the full rearing bed just one feed before the cleaning time and the feeding is given above the net. At the time of next feed the net along with the larvae are transferred to another tray and fresh feed is given only after giving sufficient spacing.

## **Moulting Care**

Silkworms settle for first moult by 3.5 days from the date of brushing if temperature (28°C) and humidity (85-90%) are maintained correctly. When worms are preparing for moult, the quantum of feed and leaf size are reduced. The last feeding has to be given as late as possible in order that silkworms can eat mulberry leaves sufficiently. If the temperature in the premoulting period is high some silkworms have a tendency to moult early without sufficient feed. If the humidity is also high the progress of the growth of the larvae become irregular. This factor to set moult with insufficient feed is stronger in races which has high ratio of cocoon shell to cocoon weight. The moulting period of silkworm which have set in moult in an insufficient feed is shorter than that of the silkworms which have set in moult in a sufficient feed. The time of setting in moult of larvae which are reared in a moist condition is postponed than that of the larvae which are reared in a dry condition.

During moult paraffin paper cover is removed and rearing bed is allowed to dry through free aeration by arranging the trays in a criss-cross pattern under box rearing. The first moult lasts for 20-24 hours. In case the progress of the growth of the larvae is irregular, the late moulting larvae should be picked up by chop sticks or gathered by netting up if they are more. The rearing bed in moulting period is to be dusted with lime powder to dry the bed fast. In general, the first feeding is performed at the time when all the larvae have exuviated. Thirty minutes prior to feeding it is good to dust bed disinfectant (RKO\* / Vijetha) @ 60- 120 g./100 Dfls in the first and second instar on newly moulted larvae. The second instar generally lasts for 2-2.5 days. Litter cleaning of premoulting period in the second instar is to be performed some what early in order to reduce the missing larvae. All the premoulting conditions are followed as in the first moult. The second moulting period last for 20-24 hours.

## **Transportation of Young Age Silkworms**

Young age silkworms reared in chawki rearing centres are normally distributed in the third instar after one or two feeds when they have gained enough strength to stand long distance transportation. They are transported in rearing trays when the quantity is less. Sometimes the rearing bed is rolled along with mulberry leaves and both end of the roll are clipped and transported after arranging in wooden trays in a single layer. During this type of transportation it is possible that heat is generated inside the rearing bed and make the larvae weak and susceptible to disease. In Japan larvae reared in co-operative rearing centres are generally transported when the larvae are under second moult. When larvae are under moult transportation is easy provided care is taken not to damage the larval body. Since mulberry leaves are in dry condition heat will not be generated in the rearing bed and the farmers can resume after moult with their own garden leaf.

The maximum distance to be covered during transportation is 100 km. or 3 hours journey distance. Journey for more than 3 hours is not advisable. Usage of small vans for transportation is advisable. It is also desirable that worms are transported during the cooler hours of the day

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\* *Resham Keet Oushadh formulated by CSR&TI, Mysore and produced and marketed by many companies.*

either early in the morning or late in the evening, so that any damage due to high temperature can be avoided.

### **Chawki Rearing Centres and its Management**

In India the concept of chawki rearing technology with modifications suited for tropical conditions was introduced in 1970. The advantages of establishing chawki rearing centres, their merits over direct brushing by farmers and their role as a centre for learning and insemination of new technology and materials are well established. However, they are not yet as popular as they are expected to be. The difference in cocoon yield between chawki reared batches over direct distribution was significantly high. In the present context organising of chawki rearing centres in large numbers and managing them effectively is a challenging task which needs immediate attention to bring stability in crop performance.

### **Problems in Running Chawki Rearing Centres**

A survey on the working of CRCs has brought into light several technical, managerial and organisational problems contributing to the poor standard of most of the existing CRCs.

- a) Lack of well maintained chawki mulberry garden. Most of the CRCs conducted rearing with leaf brought by individual farmers.
- b) Lack of infrastructure and low rate of adoption of new technologies. Most of the CRCs lack facilities for maintaining temperature and humidity and were not having sufficient technical knowledge in young age silkworm rearing.
- c) Ineffective disinfection and lack of hygiene in rearing house.
- d) Managerial problems like lack of technical competency in workers, problems in planning the quantity of rearing per batch and number of crops in a month, labour deployment etc.
- e) Organisational problems like disparity in the distribution of CRCs in relation to mulberry area and number of farmers. CRCs should match the area based requirement.
- f) Under utilisation of CRC capacity to below 50% in most of the cases.

### **Basic Considerations for Establishing CRCs**

a) **CRC link to the prospective area** - The average mulberry holding per sericultural farmer in irrigated area is about one acre and in rainfed condition two acres. Considering that one CRC should serve minimum of 100 farmers, a CRC model linking to 100 acres under irrigated and 250 acres under rainfed condition is desirable.

b) **Brushing capacity** - In general the laying requirement for one acre of mulberry is 1000 Dfls under irrigated and 400 Dfls under rainfed conditions. Thus the model CRC should have a brushing capacity of one lakh Dfls in a year in both irrigated and rainfed area.

c) **Number of crops in CRC** - The rearing of first and second instar silkworm is considered as chawki. The rearing period is about 8 days. Another four days are required to complete chawki distribution, cleaning, disinfection etc. Thus each batch will take 12 days. Hence it will be safe to plan for fortnightly brushing in CRC and 24 crops in a year. CRCs can plan for 5000 Dfls per batch.

**d) Chawki leaf requirement** - Out of the total quantity of leaf for silkworm rearing 0.33 % and 1 % are required during first instar and second instars. This is about 4 Kg and 13 Kg for 100 Dfls. It is safe to plan leaf requirement at the rate of 20 Kg for 100 Dfls in the case of bivoltine and 15 Kg for multivoltine. CRC will have to plan for production of 24 M.T. of chawki leaf to suit annual brushing of one lakh Dfls.

**e) Chawki rearing building** - The size of the chawki rearing building depends upon the quantum of brushing at a time. The building should accomodate a small office, store room, leaf preservation room and rearing room. Model suggested can accomodate 3500 Dfls in each room up to second moult. Number of rooms can be increased or decreased depending on the rearing capacity.

**f) Size and number of rearing trays** - For 100 Dfls rearing 52 sq. ft. rearing bed area is suggested till second instar. Wooden rearing trays of size 4'x 3'x 4" can be used for rearing chawki worms. 25 Dfls can be reared in a tray up to second moult. Rearing of 5000 Dfls require 200 wooden trays. Since the height of the tray is only 4", 12-15 trays can be piled up one over the other on a chawki rearing stand.

Chawki rearing centre should be a self sufficient unit in respect of all its requirements to achieve the desired results. Chawki rearing can be practised profitably on large scale as a commercial venture. The economics of organising a chawki rearing centre with an annual capacity of 1,20,000 Dfls is given in Annexure 1 which is based on the assumption that the land is taken on lease and the chawki rearing house and rearing equipments as fixed asset. The capital for maintainig mulberry garden and cost of running the chawki rearing centre are borrowed from bank source at 12% interest per annum with repayment period of 5 years. Supporting break up figures on cost of establishment of mulberry garden, labour wages, chawki rearing cost etc. are given sepeartely. The cost of chawki rearing works out to Rs. 124/- for 100 Dfls. Hence chawki rearing can be organised profitably in commercial line if the selling price of chawki reared worms are kept at Rs. 150/- for 100 Dfls.

## **Conclusion**

Failure of silkworm crop is often traced to bad management and rearing of young silkworms. Silkworm rearing techniques especially that of young age rearing have undergone many changes based on the principles of mulberry cultivation, silkworm larval growth, silkworm physiology and nutrition. The guidelines given with regard to incubation, black boxing, raising of chawki garden and maintenance of environmental conditions will help in raising healthy young silkworms with resistance to diseases. The suggestions provided on organising commercial chawki rearing centres will help in overcoming the problems and running them in a more efficient way under tropical condition to bring out crop stability. In all the sericulturally developed countries stability in crop performance was mainly achieved through supply of robust young age silkworms. By doing young age rearing in chawki rearing centres it is also possible to introduce synchronisation of crops at least in village level which can eventually help in checking diseases at a large level.

## Annexure 1

**Rearing House and Rearing Equipment for Rearing 10000 Dfls**

Sl.No.	Items	Quantity	Amount (Rs.)
1.	Rearing House (2800 Sq. ft.)	1	280000
2.	Wooden chawki stand (6'x4'x1')	20 Nos.	10000
3.	Wooden rearing trays (3'x4'x3")	400 "	60000
4.	Feeding stands	6	900
5.	Microscopes	2	2000
6.	Wash basin stand	3	600
7.	Foot cleaning mat	5	750
8.	Leaf chamber	4	2800
9.	Nylon cleaning nets (1 cm sq. mesh)	800	2400
10.	Antwells	80	400
11.	Humidifier	4	40000
12.	Room heater	6	60000
13.	Wet and dry thermometer	3	1200
14.	Chopping board	2	500
15.	Chopping knife	2	150
16.	Leaf baskets	10	250
17.	Power sprayer	1	15000
18.	Masks	1	1000
19.	Chop sticks - 8" length	6	-
20.	Plastic basin - 15" dia 6" deep	6	300
21.	Litter basket	3	225
22.	Feather	6	-
22.	Mosquito net	2 mtr.	80
23.	Paraffin paper/blue polythene sheet	200 mtr.	1500
24.	Rexin cloth	2 mtr.	100
25.	Black paper 3'x4' size	100 sheets	200
26.	Formalin	10 ltr./crop	100
27.	Resham Keet Oushadh	20 Kg./crop	200
28.	Chappals	8 pairs	200
<b>Total</b>			<b>Rs. 490555</b>

Annexure 2

1. Cost of mulberry cultivation for chawki garden (one ha/year)

Sl.No.	Particulars	Amount (Rs.)
1.	Land preparation and maintenance	9760
2.	Irrigation	8000
3.	FYM	5200
4.	Application of FYM	732
5.	Fertilizers	3447
6.	Application of fertilizers	975
7.	Labour cost for harvesting	7930
8.	Land rent	5000
9.	Land revenue	50
10.	Miscellaneous	2000
A.	Total cost of leaf production	43094

2. Cost of chawki worm rearing (1,20,000 Dfls/year)

Sl.No.	Particulars	Amount (Rs.)
1.	Depreciation of cost of building and equipments per year	32945
2.	Labour cost for chawki rearing @ Rs. 36 for 5	64800
3.	Chawki rearing maintenance cost	2000
4.	Interest on working capital @ 12%	6000
B.	Total expenditure on chawki worm rearing	Rs. 105745

A.	Cost of leaf production per ha. per year	43094
B.	Cost of chawki worm rearing per year @ 10,000 Dfls/month,	105745
	Total expenditure per ha. per year.	Rs. 148839
	Cost of chawki rearing per 100 Dfls	Rs. 124