Course Ware
Eri culture

Complied by

Dr. M.C. Sarmah, Scientist-C
Dr. B. N. Sarkar, Scientist-C
Mr. S.A Ahmed, Scientist-B

Central Muga Eri Research & Training Institute
(*An ISO 9001:2008 Certified Institute*)
Central Silk Board, Ministry of Textiles, Govt. of India,
Lahdoigarh-785700, Jorhat, Assam

Introduction

Eri is the widely spreading most popular silkworm species among commercially exploited *Vanya* silkworms. North East India is considered as the centre of origin for eri silkworm, *Samia ricini* (Donovan). Eri culture is an age old agro-based small scale industry of the region. It is purely a traditional and a leisure time occupation. The culture is practiced to meet the partial need of warm clothing. Moreover, eri pupae are popular as delicacy among the tribal people of this region. Around 1.32 lakhs families of Assam are involved in eri culture. This is not simply a traditional sericulture activity of the region but it contributes a major role in the sustainable livelihood for rural people. The R&D of eri sector is conducted by Central Muga Eri Research & Training Institute, Lahdoigarh, Assam and Regional Eri Research Stations. A total 5 comprehensive package of Practices in eri sector has been developed through intensive research as follows.

1. Package of Practices of castor cultivation and its management.
2. Package of Practices of raising of kesseru nursery.
3. Package of Practices of Kesseru cultivation and its management.
4. Package of Practices of eri seed production.
5. Package of Practices of early and late age eri silkworm rearing .
6. Management of pest and disease in eri food plants and eri silkworm

1. PACKAGE OF PRACTICES OF CASTOR CULTIVATION AND ITS MANAGEMENT.

The eri silkworm is multivoltine and polyphagous in nature feeding on a number of host plants. Castor (*Ricinus communis*) is the primary food plant of Eri silkworm. For basic seed production and to get the highest potential yield, rearing on castor is must.

Season and climate

The ideal period for plantation is March- April in North Eastern region of India. September-October is another suitable season for raising castor. Castor is a warm season crop. However, it grows under diverse climatic conditions. In winter season (during long dry spell), its leaf yield gets considerably reduced. It is highly susceptible to water logging condition and hence, drainage is must whenever low-lying area is selected for plantation.

Soil

Flat and sloppy soil either acidic or alkaline is suitable. Water stagnation is to be avoided by adopting proper drainage system in the planting area. However, humus and sandy soil suits for luxurious growth of the plant.

Varieties

A non-bloomy red variety of castor, NBR-1 is recommended for eri silkworm rearing in North Eastern region of India (Sarmah et al., 2002). Recently, two more productive accessions Acc 003 and Acc 004 have been developed with more than 13 MT leaf yield/ha/year (Sarmah et al., 2011 and Sarmah *et al*., 2013)) and later named as NBR-2 and NBR-3 (Sarmah and Gogoi, 2012). Besides, high oil yielding varieties like Jyothi, GCH-5, GCH-4, DCH-519, DCH-177, CO_1, Aruna *etc.* are being utilized for eri silkworm rearing in non-traditional states of India among which Jyothi, DCH-519 and DCH-177 showed encouraging performance in Assam condition(Sarmah, 2006).

NBR-1

NBR-2

NBR-3

Jyothi

DCH-519

DCH-177

Tillage

Land should be ploughed 2-3 times to a depth of 20-25 cm and leveled for facilitating good root penetration and easy weeding.

Spacing

Pit system of plantation is followed for raising castor for eri silkworm rearing. For sowing of seeds, 20 x 25 x 25cm(Length x Breadth x Depth) size pits are to be prepared maintaining 1x1m spacing. In each pit, 1 kg FYM along with Urea 13 g, SSP 25 g and MOP 3 g are to be added as basal dose and covered with soil. For perennial castor cultivation 1.0x 1.5 m spacing is recommended and pruning at 1m height during March (Sarmah *et al.*, 2008).

Spacing in castor plants

Seed collection and treatment

Mature capsule of seeds are to be collected during sunny day. Capsules are to be sun dried well and seeds to be removed. Before sowing the seeds, it is necessary to treat the matured and healthy seeds with Bavistin 2 g / kg to check seed borne diseases.

Sowing

Two seeds per pit at a depth of 2.5–3.0 cm are to be sown. Germination takes place after 7-10 days. Only one healthy seedling per pit is to be allowed for vigorous growth after germination.

Application of fertilizer

In addition to organic manure (FYM), chemical fertilizer is important for better growth and leaf yield in castor. NPK @ 60:40:20 kg /hectare as basal dose at pit or after one month of germination and 30 kg nitrogen/ha as 2nd dose should be applied after attaining the age of three months by ring digging method. In case of fertile land chemical fertilizer may be avoided.

Weeding & inter-culture

A large number of undesirable weeds absorbed nutrients and moisture of soil, resulting stunted growth of castor. Regular weeding helps for luxuriant growth of castor. Besides, ploughing, hoeing, weeding are to be carried out timely after and before application of fertilizer for healthy growth and higher leaf yield.

Harvesting of crop

Four leaf harvests can be made in North East region from a single plant in a year during May-June, July-August, September-October and November-January.

Crop	**Leaf yield/acre/year (kg)**
May-June	1400
July-August	1200
September-October	1200
November-January	1000

Kesseru Cultivation

Kesseru is widely used as a best perennial food plant for eri silkworm rearing. It belongs to family Araliaceae is ranked second among all the food plants of eri silkworm next to castor. It is widely distributed in the North Eastern region of India, both in wild and cultivated conditions. Taking the advantage of its perennial nature, Kesseru is being utilized in various developmental schemes of Central Silk Board, Govt. of India like Augmentation of Eri food plant, Catalytic Development Programme, Cluster Promotion Programme, *etc*.

Eri host plant, Kesseru, *Heteropanax fragrans* (Roxb.) Seem is a perennial tree. Its leaves are hard and fibrous. It is difficult for worms, in chewing the leaves as compared to castor. However, cocoons harvested from the worms fed with Kesseru are

compact. Hence, it takes more time for de-gumming during spinning as compared to castor fed ones. Feeding of kesseru foliage during late instars rearing is more suitable.

Season

August - September is the ideal season for plantation. It requires moderate rainfall during initial period but it can withstand even high rainfall after attaining maturity.

Soil

Kesseru grows well in acidic soil. High, flat and sloppy land is better. Water stagnation is to be prevented by adopting proper drainage system.

2. PACKAGE OF PRACTICES OF RAISING OF KESSERU NURSERY

Selection of land

For nursery, flat and well-drained land is to be selected.

Season

February is an ideal season for raising nursery.

Preparation of beds

Land should be ploughed thoroughly and made it level. Prepare 6 x 2 m size beds and raise the same up to 15 cm height. Apply 6 cft FYM and equal quantity of sand per bed, mixing thoroughly with the soil. Raising of polytube nursery is convenient for supply. In necessary agronet or thatched shed is to be constructed to prevent the seedlings from high rainfall and sunshine.

Seed collection

At the time of ripening of Kesseru fruits, it should be covered with nylon net to protect from birds. Collect the ripened fruits during February and keep the same in water overnight. Next morning, fruits are to be rubbed with a gunny cloth to remove the pulp of the seeds. Keep seeds in water to separate sunken healthy and viable seeds and reject the floating seeds.

Seed treatment

Treat seeds with Envoi-M 45 @ 2-3 g per kg to check fungal disease.

Seed sowing

Sow 800 seeds per bed at a spacing of (15 x 10) cm. Cover the seed beds with a thin layer of straw to retain moisture. Daily sprinkling of water is necessary during dry season. Remove the straw after germination of seeds.

Inter-cultural operation

Attend regular weeding at an interval of 20-30 days till the seedlings attain height of 20-25 cm.

3. PACKAGE OF PRACTICES OF KESSERU CULTIVATION AND ITS MANAGEMENT.

Preparation of land

For kesseru plantation, land preparation should be started during post monsoon period *i.e.* last week of July. Deep ploughing of land to a depth of 20-30 cm and leveling is recommended.

Digging of pit and spacing

For plantation, prepare 30 x 30 x 30 cm pit at a distance of 2 x 2 m spacing (in uneven hilly area 3 x 3 m spacing can be practiced to facilitate inter cropping). In each pit, apply 5 kg FYM and mix thoroughly with soil.

Transplantation

Six months old healthy seedlings (25-35 cm tall) are to be transplanted to each pit. It is more preferable to plant on a rainy day.

Cultural operation

Weeds dominate the growth of kesseru seedlings. Hence, carry out hoeing and weeding whenever required.

Application of manure and fertilizer

To get better growth and health, application of fertilizer and manure is must. During April, apply 5 kg FYM per

plant once in a year. Apply NPK @125:75:25 kg/ha in two equal split doses during April and September. Ring digging method around the individual tree base is followed to apply NPK fertilizer. Same method is followed for application of FYM manure also.

Pollarding

Kesseru plant generally grows very high but foliage is insufficient due to lack of branching. Harvesting of leaves is also a problem for its height. For profuse branching and luxuriant growth, pollarding of kesseru is very important. Pollarding is to be done after attaining the age of three years at a height of 1.75 m preferably during February. Subsequent pollarding is to be done after the interval of 3 years. Pollarding of plants should be slanting (45° angle) and opposite towards sun. Mud plastering with cow dung in the cut portion prevents diseases and pests attack.

Intercropping

To generate additional income, intercropping of ginger, turmeric and colocasia can be done in the interspaces of kesseru plantation. During gestation period of kesseru plantation, castor plant can be raised in the interspaces of kesseru. However, during mature stage of kesseru plantation, castor cannot be raised as intercrop in the kesseru plantation.

Intercropping with turmeric, colocasia and ginger in kesseru plantation.

Harvesting of leaf

In the mature plant of kesseru, three leaf harvests can be done in a year during April-May, August-September and December- February. Thus, 1000 dfls can be reared throughout the year from one acre kesseru plantation raised in 2 x 2 m spacing.

Crop	**Leaf yield/acre/year (kg)**
April-May	4500
August-September	3500
December-February	2000
TOTAL	**10,000**

Eri Seed Technology

Eri is the only silkworm reared completely indoor among the *Vanya* silks. Further, *Samia ricini* (Donovan) is the single species of saturniidae that has become fully domesticated.

Seed production is the most crucial aspect in sericulture. Cultivated eri silkworm is multivoltine and there is 4-5 overlapping generations in a year. The farmers of the North Eastern region of India practice eri rearing throughout the year. Eri silkworm is hardy and resistant to diseases in comparison to other silk producing insects. But the pebrine disease occasionally create problem. Traditional eri rearers give less importance in disease free seed production resulting occasional crop loss or low production. Management of quality seed production is very important by adopting scientific methods in different phases of egg production.

The eri seed production is not uniform in all seasons. Particularly, summer season is not suitable for seed production due to adverse climatic condition. The embryonic development stage in silkworm is very susceptible to environmental conditions i.e. temperature, humidity *etc*. and is greatly influenced by quality seed cocoons. Further the amount, rate and quality of food consumed by a larva influence the different parameters like growth rate, developmental time, final body weight, survival and reproductive potential as well. Atmospheric humidity influences directly on the silkworm pupal growth. Fluctuation of temperature and humidity has significant influence on grainage characters, such as, irregular emergence of moth, occurrence of cripple moth and unhealthy moths. The effective improved technique of eri silkworm seed production is most important to fulfill the demand of seed for the eri rearers. The important areas required to overcome the constraints in enhancing eri seed production, the improved technology of seed production needs to be practiced in farms and farmers levels. The quality seed cocoon, suitable grainage house, optimum temperature & humidity, improved grainage technology, skilled workers are the basic criteria for production of quality eri seed.

We have to follow certain definite steps for qualitatively and quantitatively better eri seed production as follows (Sarkar and Sarmah, 2012).

4. PACKAGE OF PRACTICES OF ERI SEED PRODUCTION.

Seed is the back bone of sericulture industry. Rearing of disease free quality seed is utmost important for production of quality cocoons. Generally rearers are producing their required seed of their own without assorting any scientific approach which causes outbreak of diseases and with poor harvest. Improved technology has been developed by the institute for production of disease free eri silkworm seed.

Eri Grainage house

A Grainage room having a working area of 34 feet length x 18 feet breadth x 12 feet height all round verandah of 5 feet x 6 feet is required to produce 5,000 dfls per crop. The preferable temperature and humidity is 25 $\pm$ 2 ºC and relative humidity of 75 $\pm$ 5 %. The room should be preferably east facing with provision for proper ventilation. The plinth of the grainage room should be elevated, dry and damp free. The concrete floor is suitable for grainage room for easy cleaning and washing. Separate space should be kept for seed cocoon storage, oviposition and pupa/mother moth examination in the grainage house. The suitable environment of the grainage house is always influenced on the better and optimum moth emergence, pairing, fecundity and hatchability. A low cost bamboo made grainage house should have concrete floor, mud plastered wall with thatched roof to maintain optimum temperature in all seasons.

Thatched roof, mud wall and concrete floor. Temperature of 24 - 27 °C and Relative humidity of 75 - 80 %. Dry and cool with hygienic conditions inside the rearing room.

Appliences and Chemicals for Commercial Grainage operation

To carryout the grainage operation, following equipment and appliances are required for production of 25, 000 dfls per year in 5 grainage operations.

Sl.No.	Items	Size/specification	Quantity
	Wooden racks	3.5 m x 0.5 m with 3 selves.	6 nos.
	Cocoon preservation cages	1.0 m x 0.5 m with bamboo or wire mesh.	54 nos.
	Kharikas	Thatch grass/ tree twig make	10,000 nos.
	Cotton threads	Soft cotton	40 nos.
	Eye protecting glasses	Standard	6 pairs
	Weighing balance	Electronic 0.1 g to 500 g	1 no.
	Musk	Plastic	6 nos.
	Bucket	20 litres capacity	5 nos
	Bleaching powder	30 % Chlorinated	20 kg
.	Lime powder	Slaked	40 kg
.	Max. & Min. thermometer	Digital/manual	1 set
.	Hygrometer	Digital/manual	1 set
.	Hand gloves	Rubber	6 pairs

.	Sieve	Steel with 30 cm diameter	2 nos.
.	Moth crushing set	Brass made 20 hole set	3 sets
.	Microscope	Compound	2 nos.
.	Sprayer	Foot/hand sprayer	1 no.
.	Scissor	Steel	4 nos.
.	Bloating paper	Standard	50 sheets
.	Formalin	Commercial	2 litres
.	Slide and cover slip	Standard	20 packets
.	Examination table	Wooden 2 m length x 1.0 m breadth x 1 m height	1 no.
.	Stool	Wooden/steel	4 nos.
.	Potassium hydroxide / carbonate	Laboratory grade. 500 g.	4 bottles

Disinfection of Grainage room and appliances

Disinfection is the act of destruction of disease causing pathogens. A disinfectant is an agent that has the capacity to destroy germs or harmful microorganism. To ensure the successful grainage operation, the grainage room and grainage appliances should be disinfected properly. Disinfection is very important task for controlling the pathogen during grainage operation. In the tropical country like India high temperature and high humid condition make multiplication of pathogen very high and spread the disease quickly in the un-hygienic condition. Following processes are used for disinfection of grainage appliances.

Mechanical

- Sun drying in hot sun 6-8 hours
- Burning with flame gun

Sun drying in hot sun:
Sun drying of grainage appliances in the hot sun for 6-8 hours control the growth fungal mycelia / conidia and others germs or harmful microorganism. This process is simple and recommended for poor farmers.

Burning with flame gun:
Bamboo made moth cage, bamboo or plastic collapsible mountages are generally disinfected with flame gun to control the different types of germs and pathogens.

Chemical

Different types of chemicals are used as disinfectant in grainage operation like bleaching powder, chlorine dioxide and slaked lime. For the disinfection of grainage appliances, bleaching powder is recommended.

Use of bleaching powder

Bleaching powder is chlorinated lime and has characteristic pungent smell of chlorine. Its effectiveness is dependent on the level of chlorine in the compound. Generally, 30 % chlorinated bleaching powder is useful for disinfection purpose of grainage appliances in eri culture which has strong oxidizing action for germ control. 5 % bleaching powder solution is generally useful for disinfection of grainage appliances or grainage room.

Preparation of 5 % Bleaching powder solution

For 5% bleaching powder solution, 500 gm of bleaching powder is added with 10 liters of running water. Mixed the bleaching powder thoroughly with a rod and allowed to settle for some time. The solution is preferable to be filtered through a layer of thin cloth to avoid larger particle of lime in the solution. The sediment of the solution should be discarded and only the supernatant solution are collected and used for disinfection of grainage appliances using spray machine.

Method of using of bleaching powder solution:

Spray the grainage room and appliances with the prepared bleaching powder solution. Wash or Dip the grainage appliances (moth cage, cocoon preservation tray, *kharika* etc.) in 5 % bleaching powder solution. After proper disinfection of grainage appliances, the appliances should be dried in sun light before the grainage operation. For the disinfection of floor of the grainage room 5 % bleaching powder solution @ 1 liter solution / 2.5 sq. m. is useful. Drenching grainage hall with 5 % bleaching powder solution and finally washing with clean water is essential. The whole process should be completed before 3-4 days of grainage operation. Disinfection mask, hand gloves, *etc.* should be used while disinfecting the grainage room or appliances to protect from the health hazard.

Before processing for the seed cocoon ensure that there is no any smell or residual effect of chemical disinfectant (bleaching powder etc.) in the grainage room or appliances.

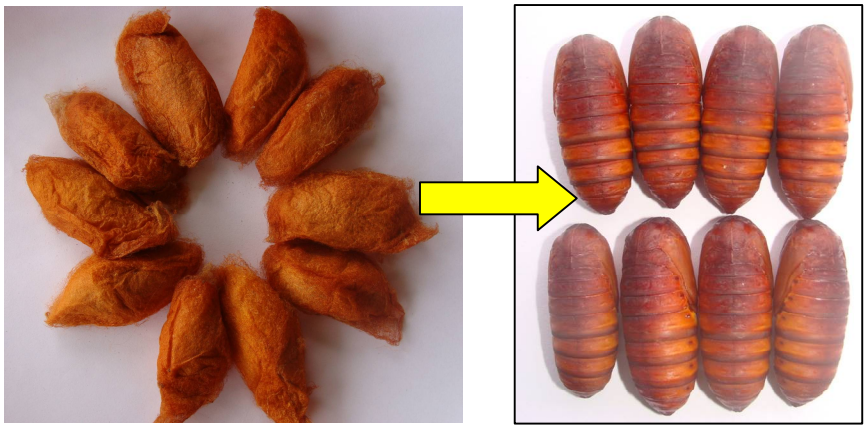
Slaked lime:

It is widely used bed disinfectant and drying agent in sericulture, which has good antiviral activity. It is very effective as dust in improving general hygiene in the grainage operation. Lime stone or $CaCo_3$ is burnt to produce quick lime (CaO) which when hydrated forms slaked lime $Ca(OH)_2$ which is used as disinfectant in eri culture.

Method of use:
Mix slaked lime with bleaching powder (1:19) and the mixture is used for dusting at the entrance and around the grainage house to maintain dryness with proper hygiene.

Seed cocoon collection and transportation

Seed cocoon should be collected after complete formation of pupae inside the cocoon. Generally in favourable climatic condition, pupation completes within 6-8 days and in winter it takes 8-10 days. Before harvesting of the seed cocoons, the maturation of the pupae can be checked by cutting some sample cocoon. Date wise collected ripened worms for mounting should be maintained separately for synchronization of moth emergence and to get maximum coupling.



After harvesting, the cocoons should be transported in bamboo or plastic baskets with sufficient aeration to the grainage room. While transporting the seed cocoons, the following precautions should be observed:

- Seed cocoons should not be transported in sunny hours and exposure to direct sunlight should be avoided.
- Seed cocoon should not be kept near engine of the vehicle.
- Cocoons should not be transported during rains.
- Dropping / falling of cocoons over the hard surfaces and vigorous shaking of seed cocoons should also be avoided.

Selection of seed cocoons

Before consigning the seed cocoons in the grainage room, seed cocoons are to be examined visually. Stained, deformed or thin layered, pierced, uzi infested and dead cocoons are to be rejected. For checking of pebrine disease, microscopic examination of eri pupa is very essential as per recommended method. The pupa are crushed in a crushing set (mortar and pestle) adding 5-6 ml of 0.8 % potassium hydroxide (KOH) solution and test under microscope. Only healthy, well-built and uniform cocoons are considered as seed cocoons.

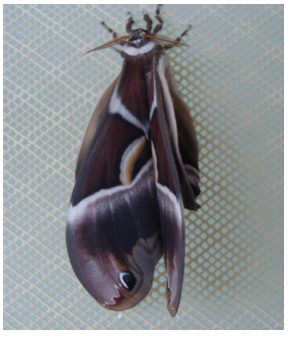
Preservation of seed cocoon

Store the seed cocoons in a single layer moth emergence cages (preferably date wise). Maintain 24 to 26 ºC temperature and 70-80 % relative humidity inside the room. Proper aeration is most essential for proper development of eri moth. Use of gunny cloth or sand bed on the floor with regular sprinkling of water on the sand bed and spray of lime powder in the grainage hall to control the temperature and humidity is recommended. Protect seed cocoons from natural enemies like ants, rats, squirrels etc. Compact grainage room and closed window and door may result emergence of cripple moth, irregular moth emergence or emergence of unhealthy moth.


Healthy seeds cocoons

Moth emergence:

Generally, eri moths start emerge early in the morning and at evening and the emergence of moths from cocoons take place after 18/19 days after spinning at 24 – 25 ºC. However, after the cocoon formation, the pupae undergo metamorphosis for 14 -15 days and develop into moth. The development and metamorphosis process differ in summer and winter seasons. The freshly emerged moths are moist, the scaly hair on the soft bodied flexible, wings are small and curled. These moths stay motionless for one hour near the cocoon or wall of the moth cage from which the moth emerges.



The male moths are smaller and active to fly, the gravid females are sluggish and have bigger abdomen with unlaid eggs inside the overiols.

Moth sorting and picking

The purpose of moth sorting is to eliminate diseased and unhealthy moths, abnormal or underdeveloped wings, scaly hairs dropped and inert, inactive and incapable of copulation to improve the quality of eggs. The healthy moth with bright body, profound wings and large abdomen is considered for pairing and egg production.

Moth emergence and wing spreading takes some time, after proper spreading the wings, the male and female moths must be gathered separately to prevent injuries each other. By the time deformed and weak moths should be rejected. Within a batch of cocoons, a small quantity of exceptionally early or late emerging moths should be eliminated and not included for mating. Healthy male and female moths should be collected in the morning and kept 50:50 ratio of male : female in coupling cages.

Mating of male and female moth

Eri moths have good coupling aptitude in natural condition, mechanical coupling is not required. The optimum temperature and humidity for mating is about 23-24 ºC and 75-80 %. Generally, mating takes place after one hour of emergence ensuring 8-10 hours coupling and decoupling is required in the afternoon. Male and females moth that emerge in the evening should be kept in pairing cage whole night and collected in the morning for tying.

Picking up and tying of mated female moths

Within an hour, more than 2/3rd of emerged moths mate naturally. While picking up the mated moths, the base of fore wing of mated female moths is held with thumb and tied it on the *khorika* (small bundles of straw or a split stick 30 cm long with a hook or cut branches of trees having one hook like projection). While tying the female moth should be on the upper side and male on the down side. The *kharikas* should be hanged evenly on the string; not to be too closed to make easy separation of mated moths. There should be no sound, strenuous vibrations and bright light free in the room. The room should have proper aeration with suitable temperature 24 to 26 ºC and 70-80 % relative humidity inside the room and semi dark condition.

Decoupling

Optimum pairing of male and female eri moth is most essential to obtaining the good quality eri seed. Mating for 6-8 hours is sufficient to ensure full fertility. It is observed that eri farmers produce eggs hapahazardly in their traditional practice in the village. They allow all the moths on the hanging cloth for egg laying, where there is no any time table of coupling and decoupling. On the cloths some moth remain unpaired and some of the female lay eggs without pairing. The free female moth lay eggs on different places in scattered position, where there is no chance to get individual mother moth examination. In this unscientific process, it is difficult to obtain disease free eggs.

In the scientific methods the mated moths are separated after proper coupling. The separation of mated moths should be done gently holding the wing of female moth and then pulling down the male moth without causing injury to reproductive organs of gravid female. The separated male moths are kept in the particular moth cage and female moths

are left on the *kharika* without removing the thread. Then the *kharika* is shaken gently to let the female moth pass urine fully. Mother moths not having urinated or not having thoroughly urinated would not only have a late egg deposition, but also would contaminate their eggs when they urinate in course of egg laying. After proper coupling and decoupling process, the gravid females are ready to lay eggs, hence a shady and cool place is required for oviposition. In case of shortage of male moths, good male moths are selected, and preserved at low temperature for second time use. The male eri moth has very good coupling aptitude and hence coupled female should be kept in protective condition, otherwise the active male moth can interfere in time of egg laying.

Oviposition

Eri moths always lay egg comfortably in the vertical position on *kharika* or branch of the tree, where the number of the eggs found more than other oviposition device. The suitable temperature and humidity for egg laying is 25-26 ºC and 80-90 % in the semi dark condition. The decoupled females are allowed to lay eggs on *kharika* in a vertical position and the gravid female start laying eggs in the dark condition from evening hours to late night. A nylon oviposition device has been developed but yet to be commercially exploited (Debaraj *et al*., 2008). The female moths lay eggs in clusters. The eggs covered with more gummy substances create egg cluster, which indicate that the eggs are healthy. When the egg surface covered with less gummy substances, the eggs are not attached with *kharika* and considered as unhealthy eggs. The unhealthy eggs found in the unsuitable summer season fall down easily from the *Kharika* **.**

Eri moths do not properly oviposit in the plain surface or cellule like mulberry silkmoth, If eri moth do not get suitable egg laying device, then number of eggs remain inside the abdomen and the period of egg laying increase. They are allowed to lay eggs for a maximum period of 2-3 days. The egg laying capacity of eri moth is different in different seasons. Generally, spring and autumn seasons are suitable for eri seed production than winter and summer. The food plants have a significant role on fecundity of the eri moth. The number of eggs laid by one female moth is usually 300 – 350

numbers, but sometimes the number of eggs are found 400 – 450 in the spring and autumn season when worms are fed with primary food plants (Castor, *Ricinus communis* Linn). Pupal weight has significant influences on fecundity, larval weight and other economic characters in the subsequent generation. More pupal weight results in large moth and more egg laying.



Collection of female moths after oviposition

After 2-3 days of egg laying, the female moths are collected in morning hours and separated date wise for microscopic examination of mother moths. The poor layings and unlaid female moths are discarded with the *kharika*. Eri moth lay

90 % eggs within 2-3 days in the suitable environmental condition. The life span of the eri moth is 5-8 days depending upon the season. The eggs laid after the 3-4 days are not suitable for rearing.

Mother moth examination

In order to produce disease free laying (DFL) and to determine the presence of pebrine spores, mother moths are subjected to microscopic examination. Procurement of healthy or pebrine free seed is paramount importance in eri culture. It is observed that bacterial, fungal and pebrine diseases are common in eri silkworm. Bacterial or fungal disease can be controlled by surface disinfection and maintaining hygiene condition. But the pebrine is the protozoan disease which infect

generation to generation through mother moth. For tackling the problem of pebrine disease, mother moth is examined following individual mother moth examination and mass mother moth examination.

Requirement of equipments/materials:

For the improved centrifugal mother moth examination, following equipments / materials are required for detection of pathogen.

1) Mixie with medium size Jars: 1 no.
2) Pastel with grinder: 4 sets
3) Centrifuge (1000 - 5000 rpm) : 1 no
4) Centrifuge tube (50/100 ml): 36 nos.
5) Cyclomixer: 1 no.
6) Plastic beakers: 36 nos.
7) Funnels (10 cm diameter): 36 nos.
8) Scissors: 4 nos
9) Measuring cylinder (500 ml): 2 nos.
10) Muslin cloth: 2 mters
11) Thin glass rod: 5 nos.
12) Micro slide with cover slip: 5 packets
13) Compound microscope: 1 no.
14) Moth examination table and stool: 1 pair
15) Potassium carbonate: 500 g
16) Potassium hydroxide: 500 g
17) Bleaching powder: 5 kg
18) Cotton: 2 roll

Preparation of K_2CO_3 solution:

Add 6 g or 7 g of K_2CO_3 crystal in 1000 ml of water for 0.6 – 0.7 % standard K_2CO_3 solution. The K_2CO_3 solution is very essential to dissolve the fat bodies and tissue of the sample.

Preparation KOH solution:

Add 6 g or 7 g of KOH crystal in 1000 ml of water to get 0.6 – 0.7 % standard KOH solution. The KOH solution is very essential to dissolve the fat bodies and tissue of the sample. In time of the pupal examination the KOH solution is more suitable than K_2CO_3 solution to dissolve the fat bodies and tissue of pupa.

a) Individual mother moth examination:

This is the best mother moth examination process for basic seed production in eri sector. In the method, the abdomen part of the individual mother moth cut by scissors and crushed in a crushing set (mortar and pestle) adding 5-6 ml of 0.6 % K_2Co_3 solution or 0.6 % KOH solution. The smear of the crushed solution can be examined under the compound microscope in (15x40) or (15x45) magnification.

Now a days, whole moth testing is suggested for detection of pebrine spores. In this method the crushed homogenate are filtered and centrifuged maintaining 3000 to 4000 rpm for 3-4 minutes. The supernatants are discarded and the sediment dispersed in few drop of 0.6 % K_2Co_3 solution and examined preferably in the phase contrast microscope in (15x40) or (15x45) magnification. The moths are tested after 3rd day of oviposition for seed production.

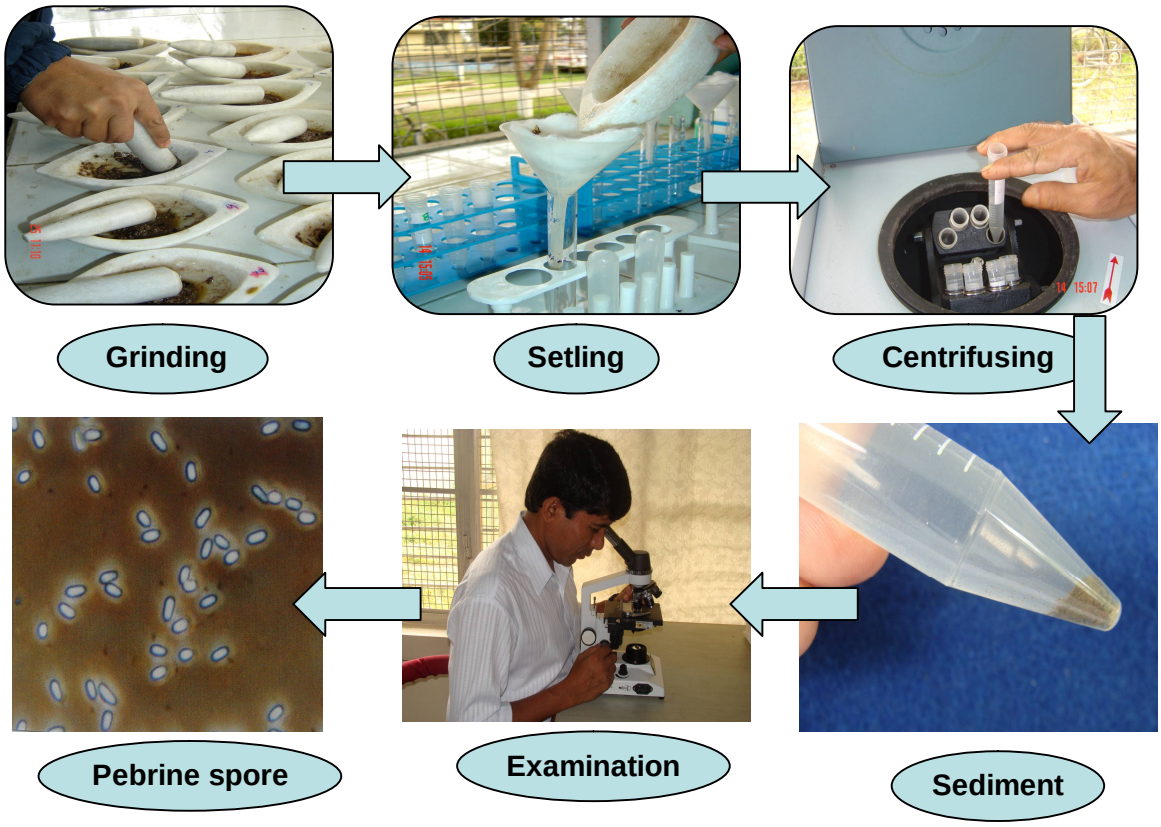
b)

Mass mother moth examination

At commercial level, it is difficult to test individual moth for detection of pebrine spore. Hence a group moth examination system has developed as an efficient method for pebrine detection. Centrifugal method of mother moth examination is effective even when the spore load is low at moth stage.

Method of mass moth examination for pebrine spore detection:

1. For 20 nos. of moths 120 ml of 0.6 % K_2CO_3 solution is required.
2. Grind the sample in the grinding machine for 3-4 minute and homogenate for 3-5 minutes.
3. Filter the homogenate through cotton and take the filtrate solution in the centrifuge tube maintaining equal amount in all tubes.
4. Centrifuge the filtrate in 4000 - 5000 rpm for 3-4 minutes for sedimentation.
5. Dilute the sediment with 0.6 % K_2Co_3 solution or in the 0.6 % KOH solution.
6. Mix the dispersed sediment in cyclomixer properly.
7. Take smear from dispersed solution and prepare slide and observe in the compound microscope preferably phase contrast microscope at 600 x magnification.
8. The phase contrast microscope is most preferable for microscopic examination of Pebrine spores.



Mother moth examination

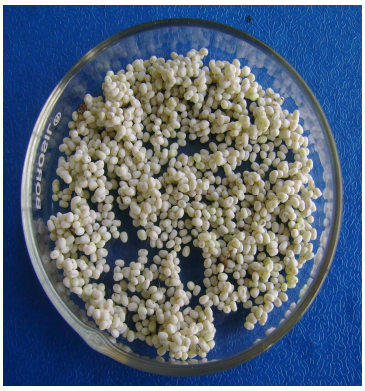
The mother moths infected with pebrine should immediately be rejected along with the *kharika*, cotton thread and eggs laid. It is advisable to burn them to destroy the pathogen. In case of detection of pebrine during egg stage, blue or pin headed stage are more suitable. Disinfection of the mortar and pestle, scissors and other appliances should be done after completion of examination by dipping in 5.0% bleaching powder solution followed by washing in soap and water before reuse. The wings, cut/crushed moths along with debris should be collected in 5.0% bleaching powder and dumped in the soak pit. The eggs are removed from the oviposition device after mother moth examination. When mother moth examination is delayed the multiplication and sporulation of pathogen takes place, resulting enhancement of pathogen in the tissue of the moth. Under the delayed mother moth examination, there is more chance to detect the pathogen than the common method of microscopic examination.

Surface sterilization of eggs

Surface sterilization of eggs should be ensured to avoid contamination. The eggs from the oviposition device after microscopic examination should be collected by dipping in 2 % formalin solution for 30 seconds and then in running water till the traces of formalin is completely removed. Surface sterilization of eggs eliminates fungal infection of eggs.

Surface sterilization of eggs helps in removal of pathogens adhering to the egg shells and also prevents secondary contamination. The eggs are then dried in the shade spreading in single layer on blotting paper for 5-6 hours in normal room temperature. The eggs should not be exposed to direct sunlight/ heat, chemicals etc. to avoid desiccation. After proper drying the disease free layings (dfls) are packed in laying boxes / muslin cloth bags for delivering to the farmers for rearing. Packing should be accompanied with the following details ascribed on a label.

- Name of the grainage.
- Name of the race / lot number
- Either weight in grams or number of eggs
- Date of egg laying
- Probable date of hatching.


Transportation of dfls

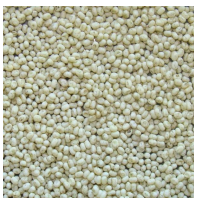
During transportation, adequate care is required to protect the eggs from exposure to climatic hazards, like high temperature, rainfall *etc*. Avoid stuffing the egg packets inside hand bags or polythene bags and ensure adequate aeration. The following measures should be followed carefully:

- Do not expose to direct sunlight, high temperature.
- Physical shock on unpaved road should be avoided.
- There should not be direct or indirect contact with chemicals, fertilizer, petroleum, insecticide, *etc.*
- Do not handle egg with contaminated hands.
- Perforated egg boxes should be used.
- Do not store eggs in poor aeration condition.
- Use moist foam pad at the bottom and sides of the egg carrying busket during hot and dry weather condition.

Silkworm Rearing Management

The domesticated variety of eri silkworm, *Samia ricini* (Donovan) is multivoltine in nature. The structure of the genitalia, wing pattern and chromosome number demonstrates that *Samia ricini* (Donovan) is derived from its wild form, *Samia canningi* (Hutton). Several eco-races like Borduar, Titabar, Khanapara, Nongpoh, Mendipathar, Dhanubhanga, Sille, Kokrajhar, Diphu, Genung etc. (Chakraviorty *et al*., 2008). of eri silkworm are available in North Eastern region of India. Depending upon larval colours and markings, six pure line strains were isolated from Borduar and Titabar eco races like Yellow Plain, Yellow Spotted, Yellow Zebra, Greenish Blue Plain, Greenish Blue Spotted and Greenish Blue Zebra. Eri silk is unique among other silks for its typical quality of white soft yarn possessing thermal properties.

In sericulture industry, rearing is the most important and critical phase. Silkworm rearing depends upon the prevailing climatic conditions of the place of rearing, availability of essential facilities/ materials like food plants, rearing house, appliances, equipments, etc. The eri silkworm is reared indoors like mulberry and can be reared five to six times all through the year subject to availability of food plants. Unlike other silkworms, eri silkworm rearing is simple and does not require high skill. Eri silkworms are hardy and less susceptible to diseases. The crops are assured as compared to mulberry, muga and tasar. However, the present trend of eri cocoon production at farmers' level is below expectation and far behind the production potential of eri silkworms. It is mainly due to lack of technical knowledge, non-availability of the essential infrastructures and mismanagement during rearing.


Eggs


1st instar worms


2nd instar worms


3rd instar worms


Moth


Cocoons


5th instar worms


4th instar worms

Different stages of eri silkworm

Therefore, well planned, managed and fulfillment of all the pre-requisites for rearing are essential to boost-up the cocoon production qualitatively as well as quantitatively. The main objective of silkworm rearing is to get high profit, which can be

achieved by producing good quality cocoons in large numbers. In eri culture, the cocoons are meant for silk production and the pupae for seed as well as a protein rich diet for the people of North East India. Apart from the availability of good quality silkworm seeds, proper disinfection and maintenance of hygienic conditions of rearing room, appliances, maintenance of optimum temperature and humidity, availability of adequate quantity of quality leaves and man-power during rearing are the major contributing factors towards the success of silkworm rearing. The arrangement and procurement of all the pre-requisites of rearing is the first and fore-most task prior to rearing. These include rearing house, food plants, rearing appliances, selection of race and season, number of crops per year, etc. The following are the different aspects of the eri silkworm rearing technology and its management (Sarmah *et al*., 2012).

5. PACKAGE OF PRACTICES OF IMPROVED ERI SILKWORM REARING AND ITS MANAGEMENT.

Availability of food plant:

A rearer has to decide the size of the rearing to be conducted after estimating the availability of eri food plants. The most common eri food plants are castor, kesseru, tapioca and payam, which are abundantly found in North Eastern region of India. Another perennial food plant Borpat, *Ailanthus grandis* is a promising eri food plant. Out of these, castor is the most preferred food plant of eri silkworm and it can be utilized throughout the year. The other food plants can be utilized in suitable seasons or interchanging among others. Maintenance of own plantation plot is essential for an effective rearing.

Rearing House:

Eri silkworms are reared indoors. The plinth area of 10 m x 5 m size rearing house having tin or thatch roofing with 1.5 m verandah all around is ideal for accommodating 100 dfls for commercial and 50 dfls for cellular stock maintenance of eri silkworm rearing per crop. The rearing houses are to be built with adequate number of windows for maintenance of a good environment and ventilators which are also to be fitted with nylon nets to stop entry of uzi flies. Efforts should be made to maintain temperature, relative humidity, light and other hygienic conditions inside the rearing house in different seasons. Plantation of evergreen trees around the rearing house should be encouraged for maintaining a better environment. The rearing house should have enough space for leaf preservation, young age and late age silkworm rearing and mounting. It should have the facility for disinfection and cleaning conveniently.

Requirement of rearing appliances:

All the required appliances and materials for rearing should be made available prior to rearing. These materials should be kept clean and disinfected properly. The following major items are required for rearing 100 dfls of eri silkworm.

Sl. No.	Name of the items	Specifications	Quantity
1	Hand sprayer	Plastic	1
2	Rearing stand (wooden)	2 m x 1.8 m x 0.50 m with 5 shelves	10
3	Feeding stand (Wooden)	1.0 m height	10
4	Rearing tray (Bamboo)	1.0 m diameter	100
5	Chandrika (Bamboo)	1.0 m x 1.0 m	100
6	Ant wells (Aluminum)	15 cm diameter	40
7	Disinfection mask	Standard	3
8	Leaf preservation chamber (Wooden)	1.5 m x1.0 m x 0.75 m	2
9	Egg hatching box (Plastic)	0.60 m x 1.0 m	100
10	Bucket	20 lit capacity	2
11	Wash basin	Standard	2
12	Wash Basin stand	1.0 m height	2
13	Plastic mug	1.0 lit	2
14	Hygrometer	Digital or wet & dry bulb	2
15	Max-min thermometer	Standard	1
16	Foam pad	40 cm x 60 cm	2
17	Measuring cylinder	1lt	1
18	Basket (Bamboo)-	--	1
19	Old news paper	--	5 kg
20	Bleaching powder	--	5 kg
21	Bird feathers	--	10
22	Slaked lime	--	5 kg

Disinfection and prophylactic measures:

Complete and thorough disinfection of rearing house and appliances is vital for successful rearing. In fact, disinfection, before and after each rearing is considered the key for a successful cocoon crop. To protect from pathogens, special attention is needed for disinfection of every nook and corner of the rearing house and appliances with proper chemicals in correct concentration. Disinfection should be carried out on bright sunny days. Some commonly used disinfectants in sericulture are formalin,

bleaching powder, lime, sodium hypochlorite and chlorine dioxide. The disinfection with 5 % bleaching powder solution is effective. Sprinkling of 2 % bleaching powder-lime mixture in the surroundings of the rearing house from time to time is good. The room temperature should be maintained at around 25 ^{o}C during disinfection. All the crevices and holes of the room should be closed to prevent entry of pests, predators, pathogens *etc*. Windows and ventilators should be kept open for proper aeration and free circulation of air.

Selection of races and season:

So far, 25 ecoraces of eri silkworm are characterized collected from different parts of North Eastern region of India, *viz*., Borduar, Titabar, Khanapara, Mendipathar, Dhanubhanga Kokrajhar, Nongpoh, Diphu, Borpeta, Imphal, Inao, Mukokchung *etc*. (Chakravorty *et al*., 2008 and Sarkar *et al*., 2012) In addition, six strains are isolated and maintained in the germplasm bank of Regional Eri Research Station, Mendipathar in Meghalaya and Central Muga Eri Research and Training Institute, Lahdoigarh. These include yellow – plain, yellow – spotted, yellow – zebra, greenish – blue plain, greenish – blue spotted and greenish – blue zebra (Debaraj, *et al*., 2001). Borduar and Titabar eco-races are better yielder among the ecoraces of North Eastern region of India (Sarkar *et al*., 2012).

Different strains of eri silkworm

The best season for eri silkworm rearing is June-October during which the rearing performance is found better (Sarmah et al., 2012). . The new eri breed C2 has been developed by hybridization of two potential parents SRI-018 (Genung) and SRI-001 (Borduar) through exerting directional selection at Regional Eri Research Station, Mendipathar, under Central Muga Eri Research and Training Institute, Lahdoigarh, Assam. (Singha, 2010). C2 breed shows best performance on feeding of non-bloomy red variety of castor (NBR-1). However, it can be reared on Kesseru (*Heterpanax fragrans*), Borpat (*Ailanthus grandis*) and Borkesseru (*A. excelsa*). The prevailing climatic conditions of the North Eastern region of India are congenial for eri culture and eri silkworms can be reared in 4 – 5 overlapping crops in a year.




Castor (NBR-1) Borpat Borkesseru Kesseru

Maintenance of environmental conditions during rearing:

The maintenance of ideal environmental conditions during different stages of rearing has a significant influence on the larval growth and ultimately a good crop. A fine weather environment refers to individual factors such as temperature, humidity, air and light. The influence of all the factors varies in different stages of larvae. It is maximum in the first instar and minimum during the fifth instar. Care should be taken not to expose the worms to extreme climatic conditions for a long period. High humidity keeps leaf fresh and silkworm feeds well but helps in outbreaks of silkworm diseases. The temperature requirement during the early instars is high and low in the late instars.


Egg incubation

Egg incubation and hatching:

Incubation is a process in which the eggs are made to hatch under an ideal temperature, humidity, light, *etc*. If the process is correctly followed, the rate of hatching and the health of the young worms will be ensured; ultimately the cocoon quality and yield also will be improved. The disease free layings (dfls) of eri silkworms are kept in the egg boxes for hatching. The dfls are kept in the paper boxes or plastic egg hatching box for uniform hatching. Incubation of eggs at optimum conditions of temperature and humidity is essential for uniform embryonic development and good hatching. Eggs should be incubated in a well-maintained room or incubator at 24-26 ˚C temperature and 80-85 % relative humidity. The colour of the egg changes to a dark bluish before two

days of hatching. This is the pigmentation stage and is very sensitive. In this stage, the egg should be kept in total darkness or wrapped with black cloth or paper. It indicates that the eggs are ready to hatch. Eggs should be exposed to light in the early morning hours (6 – 8 AM) on the expected day of hatching to get uniform hatching simultaneously. Eggs generally hatch on 9 to 10th day in summer-autumn seasons and 15 to 20th day in winter. During incubation, the eggs are kept and spread uniformly in a thin layer in the box to facilitate good hatching.

Brushing of worms:

Brushing is the transfer of newly hatched larvae from eggs to the rearing bed. The larvae hatch out in the early morning hours and continue up to 9-10 AM. On the first day of hatching, tender leaves are put inside the egg box in the early morning. The newly hatched larvae crawl onto the leaf and start feeding. The leaves along with the larvae are transferred to the rearing tray with new fresh leaves. The remaining larvae inside the box are gently transferred to the tray with the help of fine and soft brush or bird's feather. The white or creamy colour of the feather or brush is preferred to distinguish the larvae. The worms hatched in the first two days (48 hours) show more healthy, good vigour and growth; and they are considered for stock maintenance of races. However, the worms brushed in first 3 days are generally considered for commercial rearing. Preferably brushing should be completed during the early hours of the day.

Methods of rearing:

There are three methods of eri silkworm rearing, *i.e.*, traditional bunch- rearing, improved tray and platform rearing. The farmers of the North Eastern region generally employ bunch rearing method.

Bunch rearing:

In bunch rearing method, about 10-12 leaves of castor or branches of kesseru are tied together to make a bundle and hung vertically on a horizontal bamboo/wire/string support. Then the worms are allowed to feed on the tied leaves. The foliage is changed by keeping fresh bunch near the exhausted one and the worms crawl over the new one. Just below the hanging bunches bamboo mat or tray is kept on the floor so that the worms which fall down are not contaminated with dust on the floor and can be picked-up and put on the bunches. Bunch rearing is simple and easy with minimum cost but yields a better crop due to more hygienic condition. In this method, minimum manpower is utilized for bed cleaning, etc.; but strict maintenance is required like timely replacement of old bunches. Besides, there is no soiling of the leaves due to excreta of the worms as these are fallen down directly beneath the bunch. However, more worms cannot be accommodated on a bunch and more space is required for large scale rearing.

Bunch rearing

Tray rearing

Tray rearing:

In tray rearing method, the worms are reared providing the leaves on the tray. Trays are made up of either bamboo or wooden in different shapes and sizes. The shapes are round (bamboo made), square and rectangular (wooden). The young age (I-III instars) silkworm rearing is conducted either in the wooden trays of 50 x 60 x 5 cm size or in bamboo tray (1.0 m diameter). However, bamboo trays of size 1.0 m diameter is more convenient to rear 10-15 dfls until 2nd / 3rd instar; while 600-700 worms can be reared up to 4th instar and 300 worms in the final instar which also provides sufficient space.

Platform rearing technique: This is new innovative rearing method of eri silkworm (Debaraj *et al*., 2003). The model platform rearing device for eri silkworm rearing consists of 3 nos. platforms each of 1 x 2 m size and made up of bamboo strips with sieve size of 1sq cm. Platforms are placed in 3 tier in bamboo rack of size l 2.2 x b 0.75 x h 1.60 m. Two nos. of such racks can be placed in a room floor area of 5.4 sq m. (1.2 x 4.5 m). Maximum of 1200 eri silkworms at 5th instar can be reared in each platform to accommodate 7200 silkworms by brushing 25- 30 dlfs.. To collect litters of silkworm, gunny cloth is to be fitted below each tier. The technology is found to be advantageous to accommodate almost double quantity of silkworms per unit against the traditional round bamboo try (1m diameter with capacity of 300 nos. 5th instar worms) rearing system. According to quantum of rearing, size of the device may be made.

Silkworm rearing:

In general, silkworm rearing divided into two main phases, viz., i) Young age silkworm rearing and ii) Late age silkworm rearing depending upon the nutritional requirements and environmental conditions to be maintained during rearing. In both the phases of rearing, the requirements are different and the techniques of rearing are also quite distinct. The first to third instar worms form the young age and the remaining two instars (fourth and fifth) form the late age worms.

Young age silkworm rearing:

Young age silkworm rearing is also known as "Chawki rearing." A good cocoon crop at the end of successful rearing is greatly influenced by the conditions of young worms rearing. Therefore, young age worms should be reared under good rearing conditions providing them with suitable and good quality leaves. Temperature of 26-28 ˚C and relative humidity of 85-90 % are ideal conditions for young age rearing. Sufficient tender (glossy) and fresh leaves should be provided to young age larvae. Maximum care should be taken not to expose young age worms to extreme heat or cold. The young age worms are very delicate and should be handled with utmost care. In spite of normal care during young age worms rearing, the chances of loss of worms are more in first and second instar than the grown up worms.

Late age silkworm rearing:

Late age worms consist of fourth and fifth instars which need preferably lower temperature and humidity during rearing conditions. These stages consume more quantum of food than the young age worms because the worm has not only to develop silk glands and to increase growth rate, but also has to store up the reserve food materials for the future stages like pupa and imago. Therefore, these stages should be provided as much as quality food they require. The late age worms consume 80-85 % leaves supplied during the entire larval period. They attain significant growth during this stage. If the chawki rearing is conducted perfectly resulting healthy and robust worms with less mortality, the late age worm rearing will be easy with more chances of a successful crop. But proper care is essential to obtain the full potential of larval growth, maximum yield and best cocoon quality providing with sufficient food. The environmental and nutritional conditions required in late rearing are different from that of young age. The ideal temperature range 24-26 ˚C and relative humidity range 70-80 % should be maintained during the rearing of late age worms. These stages should be provided with semi-matured leaves. The feeding of dried, yellow and diseased leaves deteriorates the health of the worms and even death due to diseases. Since 80-85 % of leaves are consumed by these stages, ensure continuous supply of quality leaves after preservation in the leaf chamber.

Maintenance of larvae:

During the entire rearing period, the stage wise general maintenance of the larvae is required considering the following aspects, a) Feeding and its frequency, b) Bed cleaning, c) Spacing of worms, d) Handling of moulting worms and care, e) Collection and destruction of weak, diseased and undernourished larvae.

Feeding and its frequency:

The suitability of food plant leaves differs according to the period of larval growth. Without physical and biochemical knowledge, the leaf quantity cannot be judged according to the position of the leaves on the plants. While plucking leaf from the same shoot, the softness and the degree of maturity may vary widely according to the position of the leaves. Therefore, it is desirable to pluck more than one leaf from one shoot which appeared to be suitable for the worms' particularly young ages. After collection, the leaves should be washed in water and preserved in the leaf preservation chamber covering with wet gunny cloth / bag all around. It is better to provide castor leaves without petiole in tray rearing. 4-5 feedings should be given per day at regular intervals during the young age rearing. In late age worms, 5 feeding per day are essential. In the night time more than sufficient leaves should be provided to meet the requirement of leaf consumption throughout the night. It is advisable to prepare a feeding schedule and follow till the end of the rearing strictly.

Bed cleaning:

As soon as the larvae grow-up, the unconsumed leaves and litter increase in the rearing bed which ultimately favour multiplication of pathogenic organisms. Hence, timely bed cleaning is essential to keep the worms healthy. Frequent cleaning is better but it involves more labour and ultimately silkworm rearing uneconomical. Only one cleaning is sufficient during first stage worms. In second stage, two times bed cleaning is required. In the 3^{rd} and 4^{th} stage three times bed cleaning is required. In the fifth stage, the consumption increases comparatively more than the other instars, ultimately the bed becomes thick and damp soon. Therefore, it is necessary for daily bed cleaning in this stage. The method of bed cleaning practiced in eri culture is simple and easy. Prior to bed cleaning, the worms along with the new foliage should be transferred to a new rearing tray carefully. Maximum care should be taken not to harm the worms during handling. Bed cleaning is therefore to be accomplished through experience.

Spacing of worms:

The maintenance of optimum number of worms per unit area according to the size or stage of the worms during rearing is called spacing of worms. Proper spacing and good aeration keeps the worms healthier. Overcrowding of the worms in the tray leads to competition for food and space and ultimately undernourishment and unhealthy growth of the larvae often results in crop loss. Optimum spacing is, therefore, to be accomplished through experience. Spacing of the worms should be maintained along with cleaning. Two times rearing space is sufficient from first stage to third stage. In fourth stage, it may be necessary to increase the space by two or three times and again in the fifth stage, two times space is required to increase than the previous stages. In a standard size rearing tray (1.0 m dia), 300 number of fifth stage worms can be reared conveniently.

Handling of moulting worms and care:

A good rearing is judged by the uniformity of the larvae entering into moulting and emerging from moulting. The brushing and feeding of the worms play key role for uniform moulting, if handled properly. When worms enter to moult, stops feeding, became lethargic and less motion. If 75-80 % of the worms enter into the moult, there is no need to feed the rest of the worms. But first feeding should be provided when 80 % of the worms emerge out of moult. The worms moult four times during its larval life span. Moulting is a very sensitive period during which the worms cast off its old skin and the body is soft and delicate. The larvae take 12-36 hours to complete the moulting process during the different instars and different seasons. It is important to keep the rearing bed dry when the worms are in moult. No bed cleaning should be done during moult.

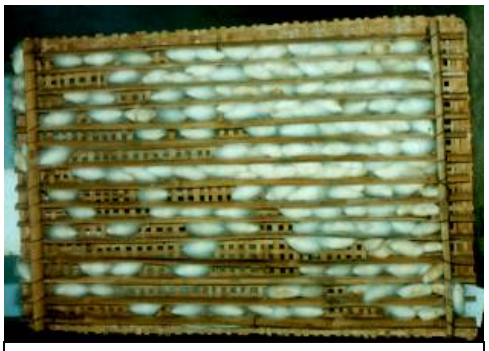
Collection and destruction of weak, diseased and undernourished larvae:

During rearing, the weak, injured, diseased and irregular worms should be collected immediately and put in 2 per cent formalin solution. Such worms should be buried or burnt carefully to prevent spread of diseases. If rearing continues mixing with these worms, the loss due to contamination and disease spread will be more; even crop failure may take place.

Matured worm collection and mounting:

After completion of larval life span, the matured 5^{th} stage larvae discard complete excreta consisting of liquid and semi-solid substances and ready for spinning cocoons. Before spinning, the worms stop feeding and become restlessly moving here and there in search of a suitable place for cocooning. The matured worms produce a hollow sound when it is rubbed gently between fingers. This is the time for picking the ripe worms and putting them on mountages.

Plastic mountage Chandraki



Bamboo strip type mountage

Before mounting process, the required number of mountages should be kept ready well in time. The worms should be collected carefully for mounting. While cocooning, it is observed that the worms require at least two supporting sides. The size of the cocoon depends upon the size of the space available for cocooning. The rearing of the worms takes place during the day time till midday. The commonly used mountages are chandraki, basket filled with dry leaves, *jali* (a bundle of dry leaves of mango, banana leaves, jack fruit, ornamental plants, etc.) and gunny bag filled with dry leaves. Besided, bamboo chandraki, plastic mountage are also used for cocoon formation. Recently, for cocooning of eri silkworm ripened worm a simple bamboo strip type mountage has been fabricated. In this mountage good cocoon recovery is 98.9% against 97.43% in conventional jail system and inferior cocoon 1.09% as compared to 2.56% in Jali. Shell weight 0.52g as compared to 0.40 g in jail (Debaraj, *et al*., 2012). The same has been recently innovated as wooden strip type mountage, which is collapsible in nature. Harvesting of 300 cocoons can be done in 3 minutes in this mountage against 30 minutes in traditional *jali*.

Wooden strip type mountage

The leaves should not be completely dried as semi-dried leaves are suitable for easy spinning. After keeping the optimum number of worms in the respective mountages, it is covered by newspaper or cloth to make support and semi-dark, a suitable condition for cocooning. However, if disturbed, it stops spinning for a short period. Due to unavailability of suitable place and disturbance, the larvae spin defective cocoon and even fail to spin cocoons. In some cases, the physiological condition inside the body is abnormal and the larvae often die without pupating. Mounting of immature and over matured larvae results in poor cocoon quality. The quality of cocoon also depends upon the type of mountages, density of worms in mounting and different mounting methods / models. During spinning, temperature, relative humidity and aeration influence cocoon quality. The ideal condition for spinning

is around 24 - 25 ˚C temperature and 60-70 % relative humidity. While mounting, the optimum number of worms should be maintained per mountage, i.e., 300 worms per chandraki of 1.0 m diameter size.

Harvesting and assessment of cocoons:

After completion of spinning, the larval skin is cast off and pupation takes place. The pupa has a thin cuticular skin which is soft and may get ruptured easily, if disturbed. The last and important step is harvesting of cocoons from the mountage in time. Cocoons should be harvested after 5-6 days of spinning in summer and 8-9 days in winter. The harvesting process is the best time of sorting of cocoons according to the quality. The cocoons should be sorted out as good, double, melted, stained, dead, inferior, cut or pierced cocoons. Good commercial cocoons should be shifted and dried perfectly after the harvest. Cocoons should be preserved carefully to protect from fungal infection and attack from pest and predators. Cocoons should be assessed on the basis of cocoon weight, shell weight and silk ratio.

Economics of ericulture

Castor based ericulture

Establishment cost of Castor plantation (Unit: 1acre)

Sl.No.	**Activities**	**Quantity**	**Rate (Rs)**	**Amount (Rs)**
Recurring cost for inputs				
1	FYM	400 cft	7	2800.00
2	Urea, SSP and MOP	80,100 &13 kg	8	1544.00
2	Castor seeds	4 kg	20	80.00
3	Insecticide/pesticide	L/S		200.00
4	Green Fencing	L/S		2000.00
Total (A)				**6624.00**
Employment generation through engagement of manpower (MD)				
1	Land preparation	20 MD	100	2000.00
2	Pit digging	20 MD	100	2000.00
3	FYM application and Seed sowing	4 MD	100	400.00
4	Cultural application (3 times)	15 MD	100	1500.00
5	NPK application	20 MD	100	2000.00
Total (B)		**79 MD**		**7900.00**
Total establishment cost of plantation (A+B) = (Ai)				**14524.00**

Cost for rearing activities

Sl.No.	**Activities**	**Quantity**	**Rate (Rs)**	**Amount (Rs)**
Non-recurring cost				

1	Rearing house (thatch house)	1	50000	50000.00
2	Platform with stand	4	300	1200.00
3	Mountage	20	60	1200.00
4	Sprayer	1	1200	1200.00
				53600.00
Total (A): Depreciated cost (10 years)				**5360.00**
Recurring cost				
1	Cost of dfls (for 4 crops)	400	2.00	800.00
2	Cost of disinfectants	L/S		200.00
Total (B)				**1000.00**
Employment generation through engagement of manpower				
1	Disinfection of rearing house (4 crops)	4	100	400.00
2	Rearing of eri silkworm (@35MD/100 dfls)	140	100	14000.00
3	Removal of pupa (2500/MD)	32	100	3200.00
Total (C)				**17600.00**
Total cost of rearing (A+B+C)= (B ii)				**23760.00**

(a)Total investment (A i + B ii)=Rs.38484.00

Return from ericulture

Sl.No.	Activities	Quantity	Rate (Rs)	Amount (Rs)
1	Sale proceed of cocoon (@8kg/100dfls)	32	300	**9600.00**
2	Sale proceed of pupa (@62kg/100dfls)	248	200	**49600.00**
	(b)Total return			**59200.00**

Net profit through rearing in Castor based ericulture: (b-a)= Rs.20716.00

Kesseru based eri culture

Establishment cost of Kesseru plantation (Unit: 1acre)

Sl.No.	Activities	Quantity	Rate (Rs)	Amount (Rs)
Recurring cost for inputs				
1	FYM	500 cft	7	3500.00
2	Urea, SSP and MOP	110,190 &17 kg	8	2536.00
3	Kesseru seedlings	1000	2	2000.00
4	Insecticide/pesticide	L/S		200.00
5	Green Fencing	L/S		2000.00
Total (A)				**10236.00**
Employment generation through engagement of manpower (MD)				
1	Land preparation	20 MD	100	2000.00
2	Pit digging	20 MD	100	2000.00
3	FYM application and planting of seedlings	10 MD	100	1000.00

4	Cultural application (3 times)	15 MD	100	1500.00
5	NPK application	25 MD	100	2500.00
Total (B)		**90 MD**		**9000.00**
Total establishment cost of plantation (A+B)				**19236.00**
Depreciated cost considering 15 years life spun of kesseru (A i)				**1282.00**

Cost for rearing activities

Sl.No.	**Activities**	**Quantity**	**Rate (Rs)**	**Amount (Rs)**
Non-recurring cost				
1	Rearing house (thatch house)	1	50000	50000.00
2	Platform with stand	10	300	3000.00
3	Mountage	20	60	1200.00
4	Sprayer	1	1200	1200.00
				55400.00
Total (A): Depreciated cost (10 years)				**5540.00**
Recurring cost				
1	Cost of dfls (for 3 crops)	1000	2.00	2000.00
2	Cost of disinfectants	L/S		200.00
Total (B)				**2200.00**
Employment generation through engagement of manpower				
1	Disinfection of rearing house (3 crops)	3	100	300.00
2	Rearing of eri silkworm (@35MD/100 dfls)	350	100	35000.00
3	Removal of pupa (2500/MD)	80	100	8000.00
Total (C)				**43300.00**
Total cost of rearing (A+B+C)= (B ii)				**50540.00**

(a)Total investment (Ai +B ii) = Rs.51822.00

Return from ericulture

Sl.No.	**Activities**	**Quantity**	**Rate (Rs)**	**Amount (Rs)**
1	Sale proceed of cocoon (@7kg/100dfls)	70	300	**24000.00**
2	Sale proceed of pupa (@50kg/100dfls)	500	200	**100000.00**
	(b)Total return			**124000.00**

Net profit through rearing in kesseru based ericulture: (b-a)= Rs.71678.00

Note: Labourers are engaged as contractual basis, not as regular wage labour.

6. MANAGEMENT OF PEST AND DISEASE IN ERI FOOD PLANTS AND ERI SILKWORM

i. Pest of castor and its management

Castor is attacked by multitude of pests. Actually it can be termed as store house of pests. Tolerance status of ten promising accessions of castor was studied against major insect pests were evaluated against Castor hairy caterpillar (Euproctis lunata Wlk.), Semilooper (Achoea janata L.), Jassids (Empoasca flavescens Fb.) and Capsule borer (Dichrocrocis punctiferalis Guen). Rate of infestation of these insect pests was recorded in different seasons. The accessions viz., ER-008, ER-009 and ER 001 were found to be resistant to Capsule borer and moderately resistant against Castor hairy caterpillar Semilooper and Jassids (Sarmah and Chakravorty, 2005). Its symptoms and control measure through IPM in eri silk sector was reported (Ahmed and Chutia, 2012).

Pest of castor its nature of damage and control measures

Name of the pest	**Nature of damage & incidence**	**Control measures**
Red hairy caterpillar	Defoliation. More destruction to young crop. Active during June – August.	**Cultural Control** • Setting of light traps (250 watts mercury lamps) on community basis with the first monsoon rains to attract the moths and kill them. • Sowing cucumber along with castor. • Placing the twigs of *Ipomoea*, *Jatropha* and *Calotropis* to attract the migrating caterpillars and kill them mechanically. **Biological control** • One scelionid egg parasite, *Aholcus euproctiscidis* and two braconid larval parasites, *Apanteles enproctisiphagus* and *Glyptomorpha deesae* have been recorded. **Chemical control** • Spray 0.05 % Monocrotophos or Chloropyriphos (0.07 %) . Trenching around the field and dusting with endosulphan 4 % to control migrating larvae.
Semilooper	Defoliation. Peak period of incidence is during	**Cultural control** • Hand picking of older larvae during

	July-September.	early stages. • Manipulate parasitic activity by avoiding chemical spray, when 1-2 larval parasites are observed on castor plant. **Biological control** • The eggs are parasitised by releasing *Trichogramma evanescens minutum* @ 50000/acre. **Chemical / Botanical control** • Spray 0.05 % Monocrotophos or 0.07 % Endosulphan if 4-5 semi-looper per plant are observed on 30 & 40 days old seedlings. • Spray neem seed kernal extract (NSKE) 4 % synchronising with egg /early larval stage. **Others** • Providing bird perches (10/acre) helps in reducing the incidence.
Tobacco caterpillar	Defoliation. Peak period of incidence during August-October.	**Cultural control** • If the area to be treated is small, collect and destroy the egg masses and caterpillars in the early stages of infestation. • Plough up the soil so as to expose the pupae **Biological control** • The braconid parasites, one larval and another egg-larval, *Apanteles prodeniae* and *Chelonus* sp. have also been recorded. **Chemical control** • To control early stage larvae, spray neem seed kernel extract (NSKE) 4 % or Spray Chloropyrifos 2.5 ml or neem oil 5 ml in one litre of water. • As the grown up larvae are nocturnal, poison bait (1 litre of monocrotophos in 10 kg of bran, 1 kg jaggery, little water to make the bait in to pellets for one hectare) placement at base of the plant helps in killing the larvae.

Hairy caterpillar	Defoliation, bore the leaves and capsules. Peak period of incidence during October-December.	**Cultural control** • If the area to be treated is small, collect and destroy the egg masses and caterpillars in the early stages of infestation. • Plough up the soil so as to expose the pupae **Chemical control** In the case of severe infestation, spray 0.05 % Chloropyriphos or 0.05 % Monocrotophos.
Capsule borer	Bores the capsule. Peak period of incidence during November-March.	**Chemical control** Spray 0.05 % Monocrotophos or dust the spike with 1.5 % Quinolphos or 2 % Methyl parathion.
Jassid	Sucks the sap from plants and hopper burn symptoms on severe infestation. Peak period of incidence during November-January	**Chemical control** • Spraying with any systemic insecticide. Seed treatment with Imidacloprid or Carbosulfan or stem application with Monocrotophos protects the crop from all sucking pests including Jassids for about a month.
White fly	Crop gives weak appearance and sooty mould is developed at severe infestation during February-March.	**Chemical control** In the case of severe infestation, spray 0.05 % Monocrotophos or 0.05 % Dimethoate.

Semilooper

Hairy caterpillar

Jassids

ii. **Diseases management in castor**

Name of the Disease	**Symptoms**	**Control measures**
Seedling blight	Young plants are affected. Both the surfaces of leaf turn yellow or brown with concentric brown zones on lower surface of leaf. Stems are also affected. Dull green round patch on cotyledons and spreads to the base.	Seeds should be treated with Thiram or Capton @ 3 g / kg and spray Copper oxychloride @ 3 g / litre.
Alternaria leaf blight	Premature defoliation Light brown spots on cotyledons turn angular with age. Inflorescence and capsules develop sooty growth. Immature capsule turn brown and fall. Affected capsules have small seeds without oil.	Seeds should be treated with Thiram @ 3 g / kg Spray 0.2 % Mancozeb.
Wilt	Wilting of plants, Root degeneration, Dropping of leaves, Necrosis of affected tissue and finally leading to death of plants	Seeds should be treated with 3g / kg of Thiram or 2g / kg Carbendazim.
Cercospora leaf spot	Both surfaces of leaf bears black or brown spots with pale green margin. Finally turn brown and falls	Spray 0.3 % Coper oxychloride or 0.25 % Mancozeb for two to three times.
Powdery Mildew	White powdery growth under the surface of the leaves	Wettable spray of 0.2 % Sulphur at 15 days interval during dry weather.

Altermaria leaf blight

Cercospora leaf spot infestation

Disease and pest management in kesseru

Kesseru plants are less susceptible to diseases and pests attack. However, attack of termite is found in most of the region. A beetle, which is nocturnal in habit, sometimes damages young leaves of kesseru plants. A Pyralid Lepidopteran pest (leaf roller) has been recorded infesting kesseru with 100 % loss of foliage. A new pest of Brown Bug, *Agonoscellis nubila* Fab. (Hemiptera: Pentatomidae) on kesseru recorded during summer (Sarmah et al., 2013).

Brown bug

Leaf roller

Prophylactic measures: Spray 0.2 % Roger or, 0.05 % Demicron or, 0.07 % Nuvan mixing with 0.7 % Endofil-M-45 @ 1000-1200 litre per hectare 2-3 times at an interval of 10-15 days, when diseases or pests attack is noticed.

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