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Sericulture Practices and Future Strategies under Present Scenario of Indian Subtropics

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The present paper deals with the mulberry cultivation technology with package of practices for successful sericulture in Indian sub-tropics. The information on leaf nutritional quality in trained and un-trained trees is provided. Besides, the current status of sericultural practices is discussed based on the problems faced by the industry and intensive field surveys undertaken in different areas of one of the most potential sericultural provinces.

Key words: Indian sub-tropics, Mulberry cultivation technology, Sericulture status in prominent belts, Leaf quality, Indian sericulture

Introduction

In India, sericulture is a cottage industry practiced in about 59,000 villages. It is labour intensive providing full and part time employment to more than 6 million people in host plant cultivation and pre and post cocoon production activities providing them livelihood and thus making it as one of the important sectors of rural economy (Singhal *et al.*, 2001a). During 2000 – 2001, India earned a foreign exchange of more than 9,000 million US $ by exporting more than 40 million square meters of silk goods. Even domestic market in India is very large and is growing further steadily. The industry provides employment both in on-farm and off-farm sectors. In India, there is a social relevance of this industry, as it provides opportunities for improving economic status of socially weaker societies. The whole of rearing operations are concentrated within their home and all family members get involved in this industry, providing thereby the job and money for their livelihood.

In India, sericulture is mostly practiced in tropical regions and Karnataka state has a monopoly producing more than 60% of the total silk production. The North Indian states, though contributes to the insignificant level in the country's silk production but nevertheless produce good export quality bivoltine silk having an excellent potential for increasing the production level further. The states comprises of Jammu & Kashmir, Punjab, Himachal Pradesh, Uttranchal and Uttar Pradesh and are delimited into two distinct sericultural zones based on the agroclimate of the area *viz.*, temperate and sub-tropical. The temperate sericulture is mostly confined to Kashmir valley of J & K state and parts of Himachal Pradesh and Uttaranchal; whereas, sub-tropical sericultural belt spreads in all the above states. The major sericultural area is the Jammu province in J & K state, which alone contributes to more than 75.0% of the total cocoon production of Indian subtropics and is represented by six prominent sericultural districts namely Kathua, Jammu, Udhampur, Rajouri, Poonch and Doda districts. Rajouri and Udhampur are the two main cocoon production areas. The province spreads in an area of about 0.97 million hectare, of which 66.46% land is under cultivation. Sericulture is a traditional industry in this province and offers congenial environment for the production of bivoltine silk. This province eventhough the homeland of sericulture, could not reach into the home traditions, because of a number of factors and the monopoly of the state government over this industry till 1989 is attributed as one of the important factors. However, with the demonopolisation of this industry, by active extension offered by the department of sericulture, Government of Jammu & Kashmir and required research support of Central Silk Board, Government of India, an upward trend in all the components of silk industry is observed. This

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includes increase in yield and quality cocoon production due to active technological support in both mulberry cultivation and silkworm rearing practices, which is also evident from the establishment of private reeling units in the region in recent past.

In view of the good potential for further expansion of the industry in this exclusive bivoltine producing area, an attempt has been made to come out with a detailed scenario on sericulture in Jammu province, *vis-a-vis.*, the future strategies for expanding the industrial base further. Detailed studies covering different aspects were taken up. Ahsan (2000) has discussed in detail the sericultural practices in vogue under temperate condition of Kashmir valley along with the future strategies. However, for sub-tropics no information is available till date. Since sericulture sustains on tree type of plantation in this part of the country, the study was initiated on quality evaluation of trees under different agronomical regimes. Besides, reviewing the earlier studies taken up in the area, sericultural production practices for mulberry and silkworm are developed and provided in this paper. Extensive field surveys were taken up for drawing up future strategies to boost silk production further in sub-tropics.

Materials and Methods

On the basis of requirement of the state, department of sericulture and the farming community of the region, an attempt has been made to consolidate the works carried out under sub-tropical conditions by the authors and other workers into an acceptable technological package. Besides, in view of the importance of mulberry leaf for successful cocoon crop, the leaf nutritional quality has been assessed in trees, since sericulture under sub-tropics sustains only on the tree type of plantation grown as block plantation under different spacings in between plant to plant and row to row *viz.*, 2.4 × 2.7 m, 2.4 × 3.6 m and 3.6 × 3.6 m, as well as grows as roadside trees. Chlorophyll and carotenoid contents were estimated by dimethyl sulphoxide (DMSO) method of Hiscox and Israelstam (1979). For analysis, leaf samples kept in DMSO were incubated in hot water bath for 1 hr and optical densities were measured in Shimadzu UV – spectrophotometer at 663 and 645 nm for chlorophyll 'a' and chlorophyll 'b' against blank (DMSO without leaf sample). Similarly, for carotenoids estimation, optical densities were measured at 510 and 480 nm. For crude protein estimation, dry leaf samples were powdered and digested in concentrated H_2SO_4 using kjeltec digestion system till colourless solutions were obtained. These solutions were then distilled in 1015 Tecator auto kjeltec system with 40% NaOH. Liberated ammonia was trapped in 4% Boric acid and titrated against 0.1N H_2SO_4 using digital autotitrator. The total Nitrogen percentage in sample was calculated and multiplied with a factor of 6.25 for finding out the crude protein. The methods of AOAC (1980) were followed for the estimation of crude fibres and carbohydrates. The ascorbic acid was estimated by the method of Ranganna (1977). The blue colour produced by the reduction of 2,6-dichlorophenol indophenol by ascorbic acid was estimated colorimetrically. In addition, extensive field surveys were conducted in prominent sericultural areas *viz.*, Kathua, Jammu, Udhampur, Rajouri, Poonch and Doda districts, for obtaining first hand information on status of mulberry field plantation, rearing villages, rearing families, silkworm seed brushed, total quantity of cocoons produced, average yield per ounce of silkworm seed and average price earned per kg of cocoons to have an insight into the actual field problems and review the technological field translation for drawing up the future strategies on the basis of studies taken up by the other workers and the detailed experiments laid out by the authors. Data on different aspects of sericulture in different districts of Jammu province have been collected for the years 1999, 2000 and 2001. The prevailing field problems in these prominent sericultural areas are discussed with future strategies.

Results

The developed technological packages on the basis of work carried out by other workers and detailed experiments laid out by the authors for the last one decade are provided hereunder:

Mulberry Production Strategies

In this province, there is only one commercial crop of silkworm rearing *i.e.*, during spring season (March – April) due to extreme climatic conditions. Therefore, mulberry is not grown by the farmers in their cultivated lands. It is grown as a tree only under natural rainfall condition either in border of the cultivated land or in the backyard of farmers house or is grown as a roadside tree. The successful mulberry tree cultivation practices includes mainly three following operations.

Raising good stock for tree cultivation: In Jammu province, good rooting mulberry genotypes found are: S-146, Chak Majra, Chinese White and Tr-10. It is investigated that the nurseries raised during winter season (3rd to 4th week of December) are more successful. However, nursery development can also be achieved successfully during monsoon period (July – August), only if proper care is

Table 1. Nursery preparation for development of mulberry tree in Indian sub-tropics

Cultural operation	Recommendation
Planting seasons	Winter (December) and monsoon (July)
Good rooting mulberry genotypes	S-146, Chak Majra, Chinese White and Tr-10
Preparation of cuttings	15 – 20 cm long cuttings of pencil thickness having 3 – 4 active buds from 6 – 9 months old plants
Nursery bed size	1.20 (L) × 4.80 (B) m
No. of cuttings to be accommodated per nursery bed	192
Application of well decomposed Farmyard Manure (FYM) per nursery bed before plantation	40 kg
Quantity of sand to be mixed with clayey soil in nursery bed before plantation	100 kg
Control of termites, the common pests	Drench soil with 5 liters of 0.1% chloropyriphos in each bed
Plantation of cuttings	Cutting dipped in 0.20% carbendazim solution for 10 – 15 min. to be planted in slightly slanting position in nursery bed
Irrigations	i) First irrigation immediately after plantation ii) Subsequent irrigation as per the prevailing climatic conditions
After 75 – 90 days of plantation	Apply 55.60 g Nitrogen, 55.2 g Phosphorus and 54.0 g Potash in each nursery bed
After 200 – 220 days of plantation	Apply 55.60 g Nitrogen in each bed
After one year of planting cutting	Sapling gets ready for uprooting and plantation as tree in field

taken, especially in avoiding water logging and planting cuttings immediately after pruning. The practices developed for proper nursery raising for this province are detailed in Table 1. However, slight changes can be made depending upon the specific prevailing environmental conditions and soil type. The main problem faced is of termites which can be checked by mixing 5 liters of 0.1% chloropyriphos in each nursery bed having size of 1.2 m length (L) and 4.8 m breadth. After one year of planting cuttings, saplings get ready for uprooting and transplantion in the field as tree.

Field plantation of saplings for developing as trees: The uprooted sapling should be planted in the pits of the size 45 cm^3 filled with farmyard manure (FYM) and sand in the ratio 1:3 by following different cultural operations as discussed by Dhar and Khan (2002). It could be trained as a tree by adopting package of practices as detailed in Table 2. Tree plantation can be developed in rows or blocks, depending upon the prevailing land availability in the region. However, in this province, farmers grow trees only in their backyards or as borders tree of their agricultural land.

Shoot harvesting technology of mulberry for commercialization of second crop: Mulberry is grown mostly as scattered trees in this province and only single pruning by way of shoot harvesting is practiced during spring season (March – April). As a result, the leaf of new branches gets over mature and, diseased by the onset of autumn rearing during September – October. To overcome such problem, only shootlets should be harvested till fourth age of silkworm rearing (April 1st week) followed by harvesting complete shoots from branches during fifth age of silkworms rearing (April 2nd week). During autumn rearing, only middle harvesting of primary branches should be followed, as they bear healthy leaves. These branches can either be chopped or used as such for rearing. The hitherto unsuccessful silkworm autumn cocoon crop can be made successful in sub-tropics by adopting this technology without distorting the crown shape of a tree.

Silkworm rearing and cocoon production in sub-tropics

The suitable rearing season of Jammu province in Indian sub-tropics is spring season (March – April). Silkworm rearing can also be performed during autumn season (September – October). The suitable crosses of silkworm hybrids for spring rearing are: $CA_2 \times NB_4D_2$, $SH_6 \times NB_4D_2$, $YS_3 \times SF_{19}$, $SH_6 \times KA$ while $SH_6 \times NB_4D_2$ and $Pam_{101} \times NB_4D_2$ are reared during autumn season. The CSR combinations like $CSR_2 \times CSR_4$ and $CSR_{18} \times CSR_{19}$ have also been recently introduced on a limited scale. However, the silkworm hybrid mainly reared is $SH_6 \times NB_4D_2$ and its reciprocal in all sericultural districts of Jammu province. The sericulture status in prominent belts

Table 2. Cultural operations for field plantation of mulberry trees

Cultural operation	*Recommendation*
Planting season	Winter (December) and monsoon (July)
Planting material	Sapling of the height more than 180 cm with girth of more than 5 cm at base
Promising genotypes	S-146, Chak Majra, Chinese White and Tr-10
Plantation in pits	45 cm^3 sized pits filled with well decomposed farmyard manure and soil in the ratio of 1:3 and about 100 g mustard oil cake
Plantation type	(i) Row type in the spacing of 3.0 – 3.6 m from plant to plant (ii) Block type in the spacing of 2.4 m from plant to plant and 2.7 m from row to row
Prunings to get crown	(i) Allow topmost 3 – 4 outlet branches in first year of plantation (ii) Again allow 3 – 4 topmost branches on each primary branch of first year. As such a crown of about 12 – 20 branches will be developed, which will take shape of a tree
Pruning in subsequent years:	
Spring season (March – April)	Shootlet harvesting till 4^{th} instar of silkworm rearing followed by complete shoot harvesting during 5^{th} instar
Autumn season (September – October)	Middle harvesting of primary branches and leaving lower over matured diseased leaves
Nutrients management:	
Block type of plantation	
a. Last week of December	FYM : 5 kg
b. During February	Nitrogen : 50 kg/ha Phosphorus : 50 kg/ha Potassium : 50 kg/ha
c. Last week of July	FYM : 5 kg
d. During August	Nitrogen : 50 kg/ha
Individual tree*:	
a. July & December	FYM: 5 to 20 kg depending upon age of a tree
b. During February	Nitrogen: 4 g in first year to 210 g by tenth year Phosphorus: 5 g in first year to 250 g by tenth year Potassium: 5 g in first year to 205 g by tenth year
c. During August	Nitrogen: 4 g in first year to 210 g by tenth year *Since leaf yield ranges from less than 1 kg to about 50 Kg/tree/year and even more in certain cases, the input requirement has to be worked out on the basis of leaf yield, age of the tree and edaphic condition of a tree

of Jammu province namely Kathua, Jammu, Udhampur, Rajouri, Poonch and Doda districts during last three years in detail is described in Table 3. The highest quantity of cocoons are produced in Udhampur district. However, average cocoon yield per ounce of silkworm seed reared was found more in Rajouri district during the year 2001. The quality of cocoons produced in this belt is found as the best gaining highest price of 6.12 US $ per kg of cocoons in the open market.

At Tikri (district of Udhampur), the average cocoon production obtained for spring 2001 was 57.78 kg per ounce of silkworm seed as against only 28.27 kg during 1998 by adopting technologies as detailed in Tables 1 and 2. Similarly, in autumn 2001, the average cocoon yield obtained was 45.00 kg per ounce of seed (Table 4). The average cocoon price for one kg of dry cocoons obtained was 6.10 US $ for spring season in the open market. The increasing trend of cocoon production in Tikri area from the year 1998 to 2001 reveals a tremendous potential for higher cocoon yield during spring as well as autumn season with the assured technological inputs in sub-tropics. Out of the new autumn specific hybrids, $RSJ_3 \times RSJ_1$ evolved at this research station has yielded 52.20, 57.40 and 49.50 kg cocoons per ounce of seed during the years 2000, 2001 and 2002, respectively at Tikri which is the higest yield among all silkworm hybrids tested during autumn rearings.

As leaf nutritional quality is the prime factor for successful silkworm cocoon crop, in the present study it was assessed in trained and untrained roadside trees during spring and autumn seasons (Table 5). The leaf quality was found superior in trained trees grown under the spacings

Table 3. Present sericulture status in prominent belts of Indian sub-tropics

Sericulture activity	year	Status in prominent sericulture districts					
		Kathua	Jammu	Udhampur	Rajouri	Poonch	Doda
Mulberry field plantation (million ha.)							
	1999	0.243	0.110	0.212	0.170	0.080	0.064
	2000	0.160	0.065	0.216	0.201	0.085	0.075
	2001	0.150	0.066	0.233	0.226	0.098	0.110
Rearing villages (No.)							
	1999	193	158	385	291	62	295
	2000	190	166	419	297	62	295
	2001	193	161	453	294	48	295
Rearing families (No.)							
	1999	2936	564	5540	7073	470	1239
	2000	2926	514	5943	6628	449	1223
	2001	2998	450	5444	4618	418	1050
Silkworm's seed brushed (ounce)							
	1999	2597	720	6115	8100	600	1270
	2000	2632	660	6268	7801	591	1210
	2001	2730	681	6249	4500	692	1365
Cocoons produced (Million kg)							
	1999	0.102	0.012	0.221	0.257	0.015	0.025
	2000	0.106	0.014	0.234	0.268	0.016	0.027
	2001	0.076	0.012	0.180	0.170	0.009	0.027
Average cocoon yield per ounce (kg)							
	1999	39.28	16.67	36.14	31.73	25.00	19.68
	2000	40.27	21.21	37.33	34.35	27.07	22.31
	2001	27.84	17.62	28.80	37.78	13.00	19.78
Average cocoon price per kg (US $)							
	1999	NA	NA	4.49	4.04	3.02	NA
	2000	4.92	4.18	5.24	4.22	3.12	3.18
	2001	5.92	5.26	5.84	6.12	4.84	3.61
No. of reeling units							
	2001	01	02	10	01	Nil	Nil

NA = not available.

of 2.4 m between plant to plant (P) and 2.7 m between row to row (R). However, untrained trees revealed poor leaf quality as compared to trained trees during both the seasons. The protein content found was as low as 16.10% in untrained roadside trees as compared to 21.12% in trained trees under the spacings of 2.4 (P) × 2.7 (R) m during spring season.

Current status of sericultural field problems of Indian sub-tropics

In Jammu province of Indian sub-tropics, still productivity is very low as compared to in tropical India. Though there is only one successful cocoon crop during spring season, there are various shortfalls at farmers level which needs immediate attention. To identify those, intensive field surveys were undertaken in sericultural areas of sub-tropics. The alarming field problems identified are mentioned below.

Mulberry tree plantation in farmers field: Due to the only one commercial silkworm rearing and main thrust directed towards agricultural crops, most of the farmers do not have their own mulberry trees for rearing. They are dependent on either roadside un-trained trees or on the

Table 4. Cocoon production in most potential sericulture area "Tikri" of Indian sub-tropics (during last four years)

Crop season	year	Quantity of green cocoons harvested per rearer (Kg)	Average cocoon yield per ounce of silkworm seed (Kg)	Average cocoon rate per Kg of dry cocoons (US $)	Highest market rate per Kg of dry cocoons (US $)
Spring	1998	20.50	28.27	4.73	7.16
	1999	31.74	35.92	4.47	5.39
	2000	43.86	55.40	6.16	7.08
	2001	41.73	57.78	6.10	7.61
Autumn	1998	13.20	33.00	3.20	3.77
	1999	13.59	36.82	3.10	3.71
	2000	11.50	35.56	3.61	4.08
	2001	15.75	45.00	5.39	6.12

Table 5. Leaf nutritional quality in mulberry variety "Chak Majra" in trained and un-trained trees (average of two years, 1999 and 2000)

Plantation type	Spacings (P) × (R)	Chlorophyll (mg/g) 'a'	'b'	Carotenoids (mg/g)	Protein %	Crude fibres (%)	Carbohydrates (%)	Ascorbic acid (%)
Spring Season								
Trained tree	2.4 × 2.7 m	2.03	0.58	0.91	21.12	12.33	9.86	2.54
	2.4 × 3.6 m	1.69	0.53	0.84	21.10	12.91	7.56	2.43
	3.6 × 3.6 m	1.67	0.52	0.81	20.59	13.27	6.80	2.28
Untrained road side trees		1.12	0.38	0.66	16.10	15.95	6.30	1.55
CD at 5%		0.48	0.16	0.29	2.38	1.86	1.93	1.01
Autumn Season								
Trained tree	2.4 × 2.7 m	1.86	0.54	0.70	18.65	12.80	7.35	1.66
	2.4 × 3.6 m	1.68	0.47	0.58	16.39	12.79	6.23	1.57
	3.6 × 3.6 m	1.55	0.42	0.57	16.38	12.78	6.19	1.12
Un-trained roadside tree		1.09	0.34	0.50	14.44	16.65	5.08	1.11
CD at 5%		0.59	0.24	0.12	2.72	1.58	1.90	0.39

P=Distance between plant to plant; R=Distance between row to row.

trees owned by other farmers for want of leaf during rearing. Due to long distance for transportation of leaf, lot of moisture gets lost and leaf quality becomes inferior. Moreover, it becomes an uneconomical proposition for the farmer. Hence, there is an urgent need for farmers to cultivate mulberry trees at least at the border of their agriculture land or in backyards of home, so that, leaf can readily be available to them without starving silkworm for any feed in time with desired leaf quality. It will further improve the economic condition of the farmer without wastage of any land meant for agriculture.

Improper disinfection: Farmers generally do not properly disinfect the rearing houses as per the advocated schedule. As a result, there is a gap between disinfection and silkworms rearing and thus rearing houses and materials get recontaminated during rearing. Moreover, in subtropics, farmers rear silkworms on temporarily prepared tiers of locally available materials and also on their sleeping cots and floors. They move freely there for feeding purpose and contaminate the rearing place. At rearing place, farmers keep their agriculture waste and household items which increases the chances of contagious diseases resulting in poor cocoon crop.

Mishandling of rearing: Most of the rearing is performed on floors and cleaning becomes a tedious job. As a result, silkworm litter gets accumulated which enhances humidity and temperature and thus makes atmosphere congenial for pathogens. It leads to high mortality as well

as poor silkworm cocoon crop.

Over crowding of worms: The over crowding of silkworms in rearing beds is the common problem for farmers. As rearing is conducted in their living rooms along with their routine household activities, very less space is available for rearing. Farmers in a greed to earn more, keeps more number of silkworms per unit of area and due to overcrowding silkworms die by starvation, increased humidity and temperature.

Improper ventilation: Most of the rearers dwellings have improper ventilation and they even keep windows and doors closed in their houses during rearing, resulting in accumulation of harmful gases, expelled by the silkworms and routine household activities of the farmers family inside the rearing houses. This leads to increase in mortality of silkworms and production of poor quality cocoons.

Poor mounting material: During spinning of silkworms, local mounting material of plant origin is generally used by the rearers. These include mustard, pine needles, *Parthenium,* etc. The mounting material is generally used fresh without drying. Due to water loss from these plants, humidity of mounting place gets further increased resulting in mortality of the silkworms. Proper aeration is absolutely required for maintaining humidity and temperature during spinning.

Improper disposal of sericultural waste: Farmers generally dispose off all their sericultural waste including diseased, dead and discarded silkworms in an open place which allows perpetuation of pathogens and spread of diseases.

Non-adoption of technologies developed: Due to lack of literacy, knowledge, resource constraints, their mind-set and other factors, farmers are just ignorant for adoption of any technology and even not ready to deviate from their traditional practices.

Inadequate rearing space: Most of the rearers do not have an exclusive rearing house/room and all the sericulture activities *viz.*, leaf storage, leaf chopping, rearing, spinning, etc. are carried out in their dwelling rooms/ kitchen resulting in poor cocoon crops. Along with shortfalls, in farmers trendset they have devised a low-cost rearing house having two tiers all around the three walls. Tiers are prepared with pruned waste mulberry twigs with roof of agricultural waste in the rearing house. Farmer attends all rearing operations by standing himself at the centre of the house. The inside temperature is quite congenial and aeration is also proper. The total cost involved in preparing such rearing house is only about 5.00 US $. Further, in an another devise, farmers made a deep bamboo grass pan which can be utilized effectively to separate out chopped mulberry leaf materials for feeding from unwanted materials like twigs, fruits and other waste by winnowing.

Discussion

In India, the contribution of sub-tropical zone for overall country's silk production is presently less than 1%. Nevertheless, the whole sub-tropics is an important bivoltine silk producing area of the country because of productive bivoltine silkworm hybrids suited to climatic conditions producing quality bivoltine silk of high demand. But, due to extreme climatic conditions, only one rearing during spring season (March – April) is commercialized. Autumn crop (September – October) is also being practiced by some of the farmers in some areas to some extent. To increase the present silk production of 1% and improve the rural economics, sericulture of sub-tropics needs new dimensions by adoption of technologies as detailed in the present paper.

The main problem is the poor quality of mulberry leaf used by the farmers because of the poor method of harvesting, transporting and storing of leaf. To overcome such problems, mulberry cultivation as trees in the borders of the agriculture field or home backyards is suggested as per the technologies described to avoid transporting leaf from far distances and thus spot availability of quality mulberry leaf to the rearers without any loss in moisture. The problem faced during autumn rearing is still more when branches gets over mature and diseased by the onset of rearing. Further, individual leaf plucking and complete shoot harvesting have a number of demerits (Dhar and Khan, 2002). To overcome it, shoot harvesting technology as mentioned in results can be adopted for successful autumn rearing. It has been reported that mulberry leaf yield can be increased by 6.57 to as high as 18.52% by adopting this technology (Misri *et al.*, 2002). In sub-tropics due to only one successful silkworm crop, no importance has been paid towards cultural practices. As, it is the leaf quality which ultimately is responsible for the successful silkworm crop (Singhal *et al.*, 2001b) mulberry trees have to be trained for desired leaf quality as revealed by the present study. For continuous nutrient supply, an integrated nutrient management was advocated by using composting technology for available natural farm waste at farmers field (Singhal *et al.*, 2001a).

Among prominent sericulture districts, Udhampur and Rajouri were identified for higher cocoon yield. Moreso, Tikri was identified as the most potential sericultural zone and suggested for exploitation specially for autumn rearing. As the silkworm hybrid $RSJ_3 \times RSJ_1$ has performed with highest cocoon yield, it needs to be exploited for autumn season and popularized in other sericultural belts for successful autumn rearing. Bakshi *et al.* (2003) have suggested that in whole of the Jammu province of Indian sub-tropics, cocoon production during autumn season can be increased by about 20 – 25% by adopting technologies and season specific hybrids.

The present study revealed that not much importance is being given for disinfection of rearing houses and as a result at many places, crop failed due to diseases. In this regard, a practical technology suggested can be used for comprehensive management of diseases in silkworm rearing (Balavenkatasubbaiah *et al.*, 1999; Illahi *et al.*, 2003). The poor wet mounting material has been found as one of the main causes for mortality. In this regard, Rajan *et al.* (1996b) suggested to use dried mounting material disinfected by spraying 0.3% slaked lime followed by spraying 2% formalin solution each at 400 ml per m^2 area. Overcrowding of silkworms caused crop failure at many places which needs proper spacing as advocated by Rajan *et al.* (1996a). Disposal of sericultural waste can be converted into compost as per the technology of Bhogesha *et al.* (1997). The studies conducted in tropical sericulture areas (Geetha *et al.*, 2001) for dissemination of technologies indicated that the socio-economic characters influence to a great extent for adoption of improved sericultural technologies by the farmers than anything else. Rao *et al.* (2002) have emphasized that farmers generally resist to new technologies because of the lack of knowledge, fear of failure and cost involved. It is, therefore, necessary to create awareness and interest among the farmers of sub-tropical zone about the new technologies so as to harvest atleast minimum two cocoon crops *i.e.*, during spring and autumn seasons. Mohandas *et al.* (2000) while surveying the most potential sericultural areas (Bangalore and Kolar districts) of Indian tropical zone found that the constraints for adoption of technologies by the farmers were mainly low awareness, non-availability of technological products and high cost of inputs. Non-adoption of technologies in sub-tropics were found in accordance with the reports from tropical parts of the country (Shankar, 1998; Singhvi *et al.*, 1996; Srinivasa *et al.*, 1996).

In sub-tropics, therefore, sericulture can be made highly profitable by adoption of technologies mainly for mulberry tree cultivation, maintaining desired leaf quality, following recommended rearing packages and exploiting potential sericulture zones, sothat, industry is found more remunerative by the farmers shifting otherwise towards more profitable trades and thereby affecting the silk production.

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