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Application Necessity of Sustainable Low Cost Technologies and Their Impact on Rural Tropical Sericulture

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Abstract: India has an exceptional advantage for the development of sericulture industry with wide spread mulberry farming, extensive accessibility of non-mulberry (vanya) silkworm food plants, congenial climatic conditions, economical man power, ever growing domestic and global demand for raw silk and a very long history of practicing sericulture. The cottage and forest based tropical sericulture activity can alleviate the rural poverty and generates employment, while its low production and productivity, however needs appropriate intervention of sustainable low cost technologies to enhance output potential to compensate increasing input costs. Though, the sericulture is viewed as subsidiary activity, its potential of continuous employment and adequate income assurance, if clubbed with the pertinent low cost technology intervention can even restrain rural migration in search of their livelihood. The technology development and its application strategy should be a collective fruitful outcome rewarding inventors, manufacturers and most importantly the end users. Further, the varied need and technology influence among consumers; regions and seasons require fine tuning for its viable application and impact. The publicity and demonstration of technologies can provide application clarity to the consumer, salability to manufacturer and motivation to inventor. The better cost benefit ratio, self life, easy operation, wider suitability, electrically independent ability, wider technology choice and technical competence of implementing workforce and end users can uphold the rural tropical sericulture needs to achieve the productivity and quality in raw silk production.

Key words: *Bombyx mori* · *Antheraea mylitta* · Mulberry and vanya silks · Low cost technologies · Tropical sericulture

INTRODUCTION

The tropical sericulture is one of the rural based agro industries with global reach and unique features of natural, ecological and economical activities of poor rural farmers in particular. The activity is labour intensive and provides gainful employment to the unemployed youth and helps to uplift the socio-economic status of rural and tribal populations, besides earning annual foreign exchange of about US$600 million to the country. Although, the quantity of silk production is declining world-wide, India is the only nation where silk production has been increasing in recent years. The global production of raw silk is approximately 70,000 tons per year, of which 16,200 tons is produced by India [1], which however accounts for only 5% of world market. The growing of all varieties of silkworms and production of 16245, 1530, 428 and 117 MTs of mulberry, eri, tasar and muga raw silk respectively by India during 2007-08 indicates the impact of silk industry on the county's economy. The limited availability of land, inadequate cash returns and agriculture being confined to one or two rain-fed annual seasons has made farmers of tropical rural areas found sericulture supporting [2]. Though in India, millions of people are employed in various fields of agriculture, the majority of small, backward and tribal families are still having their livelihood through the sericultural activities [3, 4] and however, the country's silk industry still has vast expansion potential.

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Current Status: The tropical sericultural production potential is yet to attain a realistic level due to several constraints and the major being the non availability of sustainable technology choice besides no or low adoption of existing one (s). The reasons are manifold and few of them are lack of long term application potential, cumbersome application procedure, deficiencies in availability of technology tools and technical support for effective adoption and lesser cost benefit ratio and most importantly the inadequacy of sustainable low cost technologies suit the rural needs. The feeble inventor-manufacturer-consumer linkage has influenced the co-ordination and adoption feasibility of the technology, irrespective of their suitability and potential. As the sericultural activity being a deal with the biological forms like silkworm and its food plant under rural conditions, the required agronomic practices, hygienic conditions and scientific advancement are uncertain. The situation even gets worsened with the influence of several other co-existing biotic and abiotic factors making sericulture returns very much tentative. The pressure on natural resources like land and water is considerably high following the explosion in human population in the country, affecting the horizontal expansion of many industries and hence the distinct possibility for vertical expansion through productivity increase must be thought of. Further, the sericulture activity also being practiced under tropical conditions with low water resources and hot conditions with fluctuating temperature and humidity, the food plant cultivation or silk insect growing and their successful utilization for better cocoon and silk yields certainly needs appropriate low cost technology intervention [5]. The silkworm being the poikilothermic animal and its physiological activities alter rapidly with changed environment needs suitable climate during different stages of its lifecycle through manipulation against the prevailed hot and cold conditions for its enhanced survival and silk yields [6-9]. The other vital areas of the activity which demand innovative and need-based technologies are silkworm seed production and handling [10-14], young age larval rearing [15, 16], prevention of diseases and control of pests and predators to complete silkworm larval cycle successfully to attain best possible cocoon yields and returns to compete with other alternative cash crops. In view of the new developments taking place in the field of sericulture, all forward-looking nations should consider on the rise of sustainable technologies and their application knowledge in rural tropical sericulture.

Role of Human Resource: To provide and popularize the necessary technologies in the rural areas, strengthening and expanding their application in-time becomes most imperative and paramount to reap the technology advantage. Hence, the trained human resource is one of the critical requirements for the application of technologies in rural areas and to enhance the productivity and quality of silk at a reasonable cost. The sericulture as like any other rural based industry needs effective transfer of technology and these programmes are to meet the specific needs in updating the application knowledge of technology and skills of the end users. This certainly helps in improving knowledge, skill of the consumer and to attain the optimal impact of technology in yield gain, thereby helping the participants to promote for themselves besides contributing to the industry and country. This helps establishing backward and forward linkages for sustenance of such low cost technologies suitable for rural tropical sericulture along with the future strategies for replicating or upgrading such technology. In order to achieve the potential rural tropical silk production and to meet the future demand in quality raw silk production, the innovation and application of sustainable technologies along with the strengthening of human resource through appropriate technical empowerment are indispensable.

Impact of Sustainable Low Cost Technologies: The silk production has an enormous potential in India if a suitable technology means made available to rural sericulturists on the problems and causes of uncertainty in crop success. The expansion of sustainable low cost technologies can serve as an excellent mode for employment generation and augmentation of income, besides reducing failure risks and increasing the silk yield per unit area. This situation require not only fresh and sustainable technological inputs but most importantly, establishing a channel of invention, manufacture, accessibility to consumers, technical follow-up for sound application and mid term corrections for optimal impact and output. The technology must be a low-cost, need-based, eco-friendly and sustainable one (s) being a main driver for enlargement of industry and economic growth of the country.

There is a vast untapped potential in India for wealth creation by perfecting the technology content in the entire agricultural activities with special reference to sericulture of high global market potential. Of late, the role of technology is growing and considered a component of

success with a policy to encourage technologies and to build an adequate framework to promote and sustain them. The technology role is not only about technical skill in developing a tool but also its dissemination to consumer to intervene either to arrest the damage / loss or to enhance quantity / quality. However, the introduction of something new and useful should have consistency, efficacy and cost effectiveness over the existing for its easy and speedy dissemination and field adoption. This principle has the reference of several case histories of many nations benefiting substantially from a flow of appropriate low cost need based sustainable technologies.

The biological productivity management with special reference to tropical conditions desires appropriate technologies and the success chiefly depends on in-time changeover of a critical (need based) input. The major areas of productively strong and technologically weak needs classification for developing a suitable technology to defer the damage and upkeep the productivity and quality for better sustenance. One such area in tropical sericulture is the requirement of congenial environment during the egg transportation, incubation and embryonic development, which results to higher egg hatching and successful cocoon crop. It is much more important in tropical areas, where the temperature is high with low relative humidity, which adversely affects the physiological status of seed cocoons, emerged moths during coupling, oviposition, silkworm egg viability and the success of crop in subsequent progeny. However, these can be handled systematically with simple and low cost technologies based on the principle of cooling by water evaporation, which suits for rural and tropical conditions by cost, operation and maintenance such as.

Low Cost Environator (LCE): for managing mulberry seed cocoon, mother moth oviposition and young age silkworm rearing (Fig. 1).

The silk moth, larva and eggs are sensitive to temperature and relative humidity and their fluctuations will adversely affect the cocoon crop performance. This leads to either shortage of grainage raw material in terms of viable seed cocoons for grainage activity or rearing raw material in terms of eggs/ young age silkworm larvae, forcing rearers to skip or postpone the sericulture activities. To combat such difficulty the Low Cost Environator (LCE), a multipurpose device designed to create and maintain a consistently cool and humid environment (24-28°C temperature and 75-85% relative humidity) in its inner space. The Low Cost Environator works on the principle of cooling through water evaporation with gravitational flow of water from top to bottom. It is a multipurpose device useful during oviposition of silk moth, silkworm chawki rearing and large scale incubation of silkworm eggs during hot and dry seasons. This technological innovation is highly suitable for rural areas with its electrically independent operation to substantiate silk productivity and quality.

Tasar Grainage Tool (TGT): for managing tasar seed cocoon, male moth preservation for reuse, mother moth oviposition and egg incubation (Fig. 2).

The requirement of silkworm seed based on local conditions and the inadequate seed support from the department made many tasar rearers to preserve tasar seed cocoons for seed preparation is bound to face adverse conditions and threats from predators. Further, the small quantity of cocoons kept and longer emergence duration leads to non synchronization in moth coupling and the adverse climate affects the egg laying, hatching resulting to low cocoon and silk production. Hence, a device Tasar Grainage Tool (TGT), which can suit for tasar grainage to produce better quality seed at farmers level applying the principle of cooling through water evaporation. It can maintain 24.5 to 29.8°C temperature and 74.9 to 89.8% relative humidity irrespective of the ambient conditions. The Tasar Grainage Tool can be used to preserve cocoons protecting from predators, male moths to synchronize mating, mother (female) moths for oviposition and eggs for incubation. The congenial temperature and relative humidity maintained in TGT enhances the performance of seed cocoon emergence, moth pairing, egg hatching, reduction of emergence span indicate its suitability to rural farmers, private grainages with less investment cost, easy and local fabrication, simple operation and maintenance of electrically independent nature.

Aqua Cool Incubator (ACI): for silkworm egg incubation, chawki leaf preservation in mulberry sericulture (Fig. 3).

The handling of silkworm eggs especially during incubation under tropical conditions with high temperature and low relative humidity need special attention to retain the egg viability and to have cocoon crop success. To suit the requirement, the tool devised is Aqua Cool Incubator (ACI), a low cost cooling device which can create and maintain a consistently cool and humid climate in its inner space even under extremely hot

Comparative performance of LCE

Parameter	Room	LCE	Improvement
Average temperature (°C)	33.5	26.5	- 7°C
Average relative humidity (%)	57	74	+17 %
Larval survival (%)	78.8	92.5	+ 17.3 %
Larval duration (D:H)	11-00	11-12	+12 H
Weight of 100 larvae (%)	15.9	17.8	+11.9 %

Fig. 1: Low cost environator (LCE)

Comparative performance of TGT

	Preservation method		
Parameter	Control	TGT	Improvement
Temperature (°C)	31.6 to 35.2	24.5 to 29.8	5.4 to 7.1
Relative humidity (%)	39.7 to 51.6	74.9 to 89.8	35.2 to 38.2
Cocoon emergence (%)	66.7	78.5	11.8
Moth mating (%)	57.4	73.8	16.4
Moth egg laying (%)	78.1	86.5	8.4
Fecundity (no)	231	268	37
Egg hatching (%)	78.19	85.43	7.24

Fig. 2: Tasar grainage tool (TGT)

Comparative performance of ACI

Parameter	Conventional	ACI
Average temperature (°C)	27	26
Average relative humidity (%)	83	83.5
Conditioning time	8 hours	30 minutes
Maintenance task	Frequent attention	Zero maintenance
Egg hatching (%)	96.2	97.6
Other advantages	Nil	Rat & ant Proof feature

Fig. 3: Aqua–cool incubator (ACI)

Comparative performance of TEC-AID

	Preservation method		
Parameter	Control	TEC-AID	Improvement (%)
Temperature (°C)	30.3 to 34.7	23.1 to 28.4	6.3 to 7.2
RH (%)	40.4 to 52.3	78.5 to 92.1	38.1 to 39.8
Hatching (%)	77.78	87.19	9.41
Larval growth1st age wt. (g)	0.0181	0.0193	6.63
2nd age wt. (g)	0.1870	0.2010	7.49

Fig. 4: Tasar egg carrying and incubation device (TEC-AID)

and dry seasons without employing electricity. The ACI works on the principle of rapid water evaporation and cooling, with automated voluntary absorption and spreading of water. This principle is exploited in such a way that, the surface of ACI (cooling element) can remain in wet condition consistently for days together without any manual wetting. The tool can be effectively used for the incubation of silkworm disease free layings (Dfls / eggs) and preservation of mulberry chawki leaf during hot and dry seasons. The tool also can provide perfect incubation conditions and security required for the silkworm eggs such as optimal temperature (24-28°C), relative humidity (75-85%), free air circulation, natural light and dark periods, hygiene and protection from predators.

Tasar Egg Transportation And Incubation Device (TEC-AID): for tropical tasar silkworm egg transportation and incubation (Fig. 4).

The scientific handling of tropical tasar silkworm seed (Dfls / eggs) is highly essential due to prevailed climatic conditions and their fluctuations. The tasarculture being the rural practice, where the electricity supply and protection from the predators are not assured, silkworm seed needs a suitable technology for their protection. The tool, Tasar Egg Carrying And Incubation Device (TEC-AID) is a simple, portable, suits for both egg transportation/ incubation, protects from predators, non dependent of electric/ any other power, almost requires no skill and most importantly cost effective. The TEC-AID maintains 23.0 to 28.4°C temperature and 78.5 to 92.1% relative humidity, irrespective of ambient climatic conditions, which are very much congenial for silkworm egg from its day of production to hatching. The results also showed an increase of 9.41% in egg hatching against controls and the enhanced rate of growth in larvae with 6.63 and 7.49% during 1st and 2nd stages respectively over controls. By using the TEC-AID, optimal climate required can be provided while transporting the eggs from the grainage to rearer's house, while incubating at rearer's house and also while transporting the hatched larvae from rearer's house to rearing field. The tool of simple and sustainable technology helps in scientific handling of tasar seed to make tasarculture remunerative.

Limitations: The purpose and outcome of the technology can be seen only when they sustainably intervene critical areas of application need at the right time. In spite of high potential of the technology, often they ends-up at laboratory levels instead of reaching the field for application; which needs either intervention of appropriate authority or flexibility in implementing procedures, based on its need, impact and consumer category. In spite of continuous R and D efforts and evolving several technologies to reduce the production cost of silk, the adoption rate found low and slow for want of reasonable education levels, application knowledge and skill up-gradation of majority of the farming community and field level official machinery. The inadequate links of inventor, manufacturer and most importantly the executing agency / consumer have reduced the propagation rate of innovated sustainable technologies. Further, the in-consistent follow-up on the technology implementation till the end users acquainted the operation knowledge, efficacy and cost-effectiveness has blocked the attainment of productivity and quality potential. This has a great relevance to tropical sericulture sector as many of the end users are rural based, illiterates, economically weaker and women groups.

CONCLUSION

Despite countless obstacles in optimizing the silk productivity and quality, the India still stands-out as a treasure trove of tropical sericultural prosperity. The current trend on cost benefit equation; the want is undoubtedly the intervention of sustainable low cost technologies, irrespective of the segment and rightly for rural tropical cottage, agro and agro-forestry associated fields. The problems though manifold, with a search-out for ways and means the low cost technologies of simple operation, easy fabrication, potential cost benefit equation and rural application merit needs to be popularised. The optimization of production potential, intellectual resource and application strategy can together augment low cost sustainable technologies for the best possible development of the Indian rural tropical sericulture.

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