

# sericologia

Journal of the silkworms.

Revue des vers à soie.

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### CONTENTS

### SOMMAIRE

#### Editorial

International Sericultural Commission  
Records and Information

XIVth International Sericultural  
Congress

*List of the delegates*

*Welcome speech of Mr. B. SIVARAMAN*

*Inaugural address of Mrs. CHANDRAPRABHA  
URS*

*Awarding of the Pasteur Prize 1983*

*Answer and thanks of Dr. H. BOUVIER*

Mulberry Section

*Bombyx mori* Section

#### 271 Editorial

273 Commission Séricicole Internationale  
Actes et Informations

XIVe Congrès Séricicole International

277 *Liste des Participants*

293 *Discours de bienvenue de M. B. SIVARAMAN*

299 *Discours d'inauguration de Madame  
CHANDRAPRABHA URS*

309 *Remise du Prix Pasteur 1983*

311 *Réponse et remerciements du Dr. BOUVIER*

315 Section mûrier

375 Section *Bombyx mori*.

## EDITORIAL

This issue of *Sericologia* and the following will be devoted to the XIV International Sericultural Congress report.

The great number of participants and communications led us to publish the communications of each section in separate issues.

This one concerns, besides the inaugural speeches, the "BOMBYX MORI" and "MULBERRY" sections. Papers presented in the "BACOLOGIE" section will be published in the next issue, then "NON-MULBERRY" and "SILK REELING AND HANDICRAFT" will be published together. The last issue reporting the congress will concern the "ECONOMY" section and communications of official delegates from several countries and international organizations.

Because of the space necessary for the printing of all papers, the following rules have been adopted:

Communications which have been accepted by the chairmen of the different sections will be fully published. Communications which have been submitted but not accepted for oral presentation will be published in abstract form only.

Ce numéro de *Sericologia* et les suivants seront consacrés au compte-rendu du XIVe Congrès Séricicole International.

Le grand nombre de communications nous oblige à publier le contenu de chaque section dans des numéros séparés.

Celui-ci contient, outre les discours officiels et la liste des participants, les sections "BOMBYX MORI" et "MURIER". Les communications présentées dans la section "BACOLOGIE" seront publiées dans le prochain numéro, puis les sections "SOIES NON-MURIER" et "FILATURE ET ARTISANAT" seront publiées ensemble dans le numéro suivant. Le dernier numéro consacré au congrès concernera la section "ECONOMIE" et les communications faites par les officiels de divers pays et organisations internationales.

En raison de l'espace nécessaire à l'impression de tous les articles, nous avons adopté les règles suivantes :

Les communications qui ont été acceptées par les présidents des différentes sections seront publiées en entier. Les communications qui ont été soumises mais non retenues pour une présentation orale seront publiées sous forme de résumé seulement.

## COMMISSION SERICICOLE INTERNATIONALE

## INTERNATIONAL SERICULTURAL COMMISSION

### RECORD AND INFORMATION

### ACTES ET INFORMATIONS

#### INTERNATIONAL SOCIETY FOR NON-MULBERRY SILKS

#### SOCIÉTÉ INTERNATIONALE DES SOIES NON-MURIER

In 1981, the Secretariat General of the International Sericultural Commission was informed that the International Society for Non-Mulberry Silks was founded.

On April 28, 1982, the Secretariat of the International Society for Non-Mulberry Silks was made aware that the Board of the Executive Committee of I.S.C. had examined the question of the participation of I.S.C. in the International Society for Non-Mulberry Silks. It was specified that the International Sericultural Commission, as an intergovernmental organization, could not take a part in a non-governmental organization.

In accordance with the principle of cooperation, the creation of the Society had been announced in *Sericologia* and the I.S.C. Secretariat General had suggested that the proceedings of meetings of the International Society for Non-Mulberry Silks be published in *Sericologia*.

Dès 1981, le Secrétariat Général de la Commission Séricicole Internationale a été informé de la création de la Société Internationale des Soies Non-Mûrier.

Le 28 avril 1982, le Secrétariat de la Société Internationale des Soies Non-Mûrier était informé du fait que le problème de la participation de la C.S.I. à cette association avait été examiné par le Bureau du Comité Exécutif. Il avait été précisé que la C.S.I., en tant qu'organisation intergouvernementale, ne peut pas participer à une organisation non gouvernementale.

Dans un esprit de collaboration, la création de la Société avait été annoncée dans *Sericologia* et le Secrétariat Général de la C.S.I. avait proposé de publier dans *Sericologia* les comptes rendus des réunions de la Société Internationale des Soies Non-Mûrier.

On the occasion of the symposium "Study and utilization on non-mulberry silkworms" to be held at the Hamburg Congress of Entomology in August 1984, the International Society for Non-Mulberry Silks published a Membership list. In the attached letter it is indicated that this list is wrong.

I.S.C. Secretary General Dr. H. BOUVIER makes a point of stating that, because of the reasons mentioned above, he has never applied for membership and that his name has been entered by mistake in this list. This will not prevent him from staying in friendly terms of cooperation with this society and with its members.

A l'occasion du symposium "Etude et utilisation des vers à soie non-mûriers" devant être tenu lors du Congrès d'Entomologie de Hambourg (août 1984), la Société Internationale des Soies Non-Mûrier a publié une liste de ses Membres. Dans une lettre d'accompagnement il est indiqué que cette liste est inexacte.

Le Docteur H. BOUVIER, Secrétaire Général de la C.S.I., tient à préciser que, pour les raisons énoncées ci-dessus, il n'a jamais demandé à être membre de la Société Internationale des Soies Non-Mûrier et que c'est par erreur que son nom figure sur la liste des membres. Ceci ne l'empêchera pas d'entretenir avec cette association et avec ses membres, les meilleures relations de collaboration.

XIV<sup>E</sup> CONGRES SERICICOLE INTERNATIONAL

XIV<sup>TH</sup> INTERNATIONAL SERICULTURAL CONGRESS

BANGALORE - 21 - 25 MAI / MAY 1984

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Organisations et pays qui n'ont pu participer au Congrès mais qui ont demandé à recevoir le rapport final du Congrès /  
Organizations and countries which could not attend the Congress but wish to receive the final report of the Congress :

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**WELCOME SPEECH**  
**of**  
**Chairman of the Central Silk Board**  
**B. SIVARAMAN**

Honourable Minister for Sericulture, Government of Karnataka, delegates to the XIV International Sericultural Congress and friends, I have great pleasure in welcoming you all to this inaugural function of the XIV International Sericultural Congress being held here from today to 25th May. I am thankful to the International Sericultural Commission for inviting me to preside over this function.

The theme of this Congress is Tropical Sericulture. It is in the fitness of things that this august gathering of sericulture and silk experts from all over the world will discuss tropical sericulture and that too in India, which is the largest tropical country in the world engaged in sericulture. The importance of tropical sericulture lies not in its present size but in the future role it has to play in pushing up the standards of living of a vast majority of rural people in the third world. The world production of mulberry silk was about 52,000 tonnes in 1982. Out of this, the tropical countries did not account for more than 17%. India was the largest producer amongst the tropical countries with about 5,200 tonnes production in 1982-83.

**Temperate Sericulture**

Presently China, Japan, South Korea and U.S.S.R. are the four main countries situated in the temperate zone, accounting for 83% of the production of silk in the world. A look at the production trends in each of these countries reveals beyond all doubts that excepting in China, the production is diminishing at a fast rate in these countries. Japan's production of raw silk was 43,152 tonnes in 1938. Today, Japan is producing only 12,990 tonnes per year. The South Korean production has come down from 1,279 tonnes in 1980 to 2,418 tonnes in 1982. The production in the Soviet Union is stagnating around 4,350 tonnes. It is understood that the down trend in sericulture in Japan is due to rapid industrialisation, rise in the level of industrial productivity and incomes and rapid urbanisation of the rural area. It is also said to be due to the fast diminishing demand for kimonos which used to be the main dress material for consumption of silk. The changing life styles in Japan and increasing

urbanisation and industrialisation are not compatible with continuance of sericulture at the present level. It is to be seen whether the efforts of the agencies involved in the task to create alternative sources of demand within the country, succeed in propping the demand at the present level. It is hopeful that the Government policies of maintaining parity amongst the various interests involved in silk industry succeed in ensuring the continuous profitability of sericulture. It is more or less the same story in South Korea, which has shown tremendous economic growth during the last 25 years. As far as U.S.S.R. is concerned, though technically it is possible for them to raise a second crop and increase the size of the first crop also, it is generally felt that the planners have restricted the production of silk in view of the requirements of labour for the cotton crops. China is the only temperate country which has achieved a high level of production and which can maintain and increase this production for a long time to come.

#### THE WORLD DEMAND FOR SILK

There are no systematic studies conducted for estimating the world demand for silk. The figures released by the International Silk Association and also those compiled by the Sugar and Raw Silk Price Stabilization Bureau, Govt. of Japan indicate that there is an all-round increase in the price level of silk goods despite increased production over the last 10 years. We are led to believe that the increase in price in an item like silk is not only the function of inflationary tendencies which are manifested all over the world but also an indication of the increasing demand for silk. Considering the developmental activities undertaken by all the third world countries and considering that the domestic markets in most of the producing countries are not yet fully exploited, it is reasonable to assume that the overall world demand for silk will remain far above the actual supplies for a long time to come. Apart from China, the future supplies of silk for the world markets will have to come only from the tropical countries which are mostly the countries in the process of development and where relatively cheaper labour in rural areas is available.

#### TROPICAL SERICULTURE

The reason why sericulture had not developed in tropical countries hitherto was its low productivity in tropical areas and lack of technical knowhow to increase this productivity. The Univoltine/Bivoltine races of the silkworm, which account for 100% of the production in the temperate zone were technically suited only to those zones. The high productivity sericulture thrived only in temperate zones. Today, because of the scientific breakthrough in tropical sericulture, the bivoltine races of silkworms and their hybrids have been evolved for production in the tropical countries. New high yielding varieties of mulberry in bush form have been evolved. Management practices appropriate to the socio-economic conditions of the villagers in the third world countries have been evolved. In India, the above scientific and management breakthrough has made sericulture the most profitable crop for the marginal and small farmers. The rearer can easily draw an income of Rs.25,000.00 (US\$2500 approximately) from a hectare of irrigated land. This is more than what he can earn from any competing agricultural crop. The economics given here assume the systems support to be given by the Government for extension, marketing, etc.

#### India, The Leader

As I said earlier, it is but appropriate that it is India which should be hosting the XIV International Sericultural Congress, the main theme of which is the tropical sericulture. It is in India that the scientists of the Central Silk Board have achieved a much needed breakthrough in evolving new bivoltine races suitable to our conditions, new mulberry varieties and cultivation practices suited to these varieties, easy and inexpensive methods of creating a micro climate conducive to the

rearing of silkworms, etc. As is well known to the experts gathered here, for a country of India's size, where more than 70% of the population lives in rural areas and where not more than 35% of the population is literate, one of the main strategies of achieving economic growth and full employment is the development of agro-industry. Sericulture is an agro-industry with very low gestation period and very high investment employment ratio. We in India have developed systems to give sufficient scope for private enterprise at the grass root level, and cooperative efforts at the level of servicing supplies and marketing. Government steps in to provide basic infrastructure involving heavy investments. Our system is a judicious combination of individual enterprise, cooperatives and Government. This mixed socio-economic system may be relevant not only to India but also to a majority of third world countries having socio-economic conditions similar to those in India.

It is not only in mulberry sericulture that India has made strides but we have also achieved a much needed breakthrough in tropical tasar. Whereas the traditional tropical tasar rearing used to be done on existing forest lands, the research results achieved in our tasar institute now enable us to undertake largescale plantations of arjun host plants, thereby not only bringing the waste land into cultivation and achieving the purposes of social forestry but also enabling a greater number of tribals to increase their levels of income through new plantations. As far as Eri and Muga are concerned, our scientists are in the midst of research to increase the economic significance of eri in our country and to restore the production of muga silk to its original level.

Sericulture in India is an exciting experience, it has tremendous implications for the development of the poor farmers of the country. Today, we have more than twenty thousand scientists, administrators, extension workers and managers involved in the process of sericulture development throughout the country. India is the only country today which has all the four types of commercially known silks. It is also here that we have heralded the transfer of temperate sericulture to tropical areas. It is in this sense that it is appropriate for us to host the XIV International Congress, the theme of which is Tropical Sericulture.

I once again welcome all of you to this Congress and hope that the deliberations of this Congress will lead to the increase of incomes and employment opportunities throughout the world through sericulture. I now request the Honourable Minister for Sericulture, Govt. of Karnataka to inaugurate the Congress.

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Traduction Résumée  
du  
DISCOURS DE BIENVENUE  
de  
Monsieur B. SIVARAMAN,  
Président du Central Silk Board

Madame le Ministre de la Sériciculture du Gouvernement du Karnataka, Messieurs les Délégués au XIVème Congrès Séricicole International et Chers Amis, c'est avec grand plaisir que je vous accueille à cette séance d'inauguration du XIVème Congrès Séricicole International qui va se dérouler ici jusqu'au 25 mai. Je remercie la Commission Séricicole Internationale de m'avoir invité à présider cette séance.

Le thème de ce Congrès est la sériciculture en milieu tropical. Il est normal que, pour étudier ce problème, des experts séricicoles du monde entier se réunissent en Inde qui est le pays tropical ayant la plus forte production séricicole. La sériciculture tropicale n'est pas importante du fait de sa production actuelle, mais par le rôle qu'elle devra jouer à l'avenir pour améliorer le niveau de vie des populations rurales du tiers monde. La production mondiale de soie mûrier était d'environ 52 000 tonnes en 1982. La production des pays tropicaux ne représentait que 17 % de celle-ci. L'Inde se plaçait comme le plus grand producteur des pays tropicaux avec une production d'environ 5 200 tonnes en 1982-83.

**Sériciculture en climat tempéré**

Actuellement, la Chine, le Japon, la Corée du Sud, et l'U.R.S.S. sont les quatre principaux pays producteurs de la zone tempérée. Ils représentent 83 % de la production mondiale de soie. Lorsqu'on examine quelle est l'évolution de la production dans chacun de ces pays, il ne fait aucun doute qu'à l'exception de la Chine, la production est en train de diminuer rapidement dans ces pays. La production japonaise est passée de 43 152 tonnes de soie grège en 1938 à 12 990 tonnes aujourd'hui. La production sud-coréenne est passée de 3 279 tonnes en 1980 à 2 418 tonnes en 1982. La production en Union Soviétique stagne autour de 4 350 tonnes. Cette baisse de la production séricicole au Japon est due à une industrialisation rapide et à l'urbanisation rapide des zones rurales. On l'attribue également à la baisse de la demande en kimonos. C'est à peu près la même chose en Corée du Sud qui a bénéficié d'une croissance économique très rapide au cours des 25 dernières années. En ce qui concerne l'U.R.S.S., il semble que les planificateurs aient réduit la production de la soie

afin de satisfaire les besoins en main d'oeuvre des plantations de coton. La Chine est le seul pays tempéré qui, ayant atteint un niveau de production élevé, non seulement maintienne mais est capable d'augmenter cette production.

## LA DEMANDE MONDIALE DE SOIE

Il n'existe pas d'études systématiques permettant d'évaluer la demande mondiale de soie. Les chiffres donnés par l'Association Internationale de la Soie et ceux compilés par le Bureau de Stabilisation des Prix du Sucre et de la Soie Grège du Gouvernement japonais, indiquent qu'une augmentation globale des prix des articles en soie apparaît en dépit de l'accroissement de la production au cours de ces 10 dernières années. Cela nous incite à penser que l'augmentation de prix sur un article comme la soie n'est pas seulement fonction de l'inflation qui sévit dans le monde, mais aussi une indication de l'accroissement de la demande en soie.

## SERICICULTURE TROPICALE

Le faible développement, jusqu'à présent, de la sériciculture dans les pays tropicaux était dû à un manque de savoir-faire technique. Les races de ver à soie monovoltines ou bivoltines des zones tempérées n'étaient pas adaptées aux régions tropicales. Aujourd'hui, grâce aux progrès scientifiques, des races de ver à soie bivoltines et leurs hybrides ont été adaptés à la production en zone tropicale. De nouvelles variétés de mûrier à haut rendement ont été mises au point ainsi que des méthodes de gestion séricicole adaptées aux conditions socio-économiques. En Inde, ces progrès ont fait de la sériciculture l'activité agricole la plus rémunératrice pour les paysans.

### L'Inde, Chef de File

Comme je l'ai déjà dit, il est tout à fait approprié que ce soit l'Inde qui accueille le XIV<sup>ème</sup> Congrès Séricicole International dont le thème est la sériciculture tropicale. C'est en Inde que les scientifiques du Central Silk Board ont réalisé les progrès nécessaires en créant de nouvelles races bivoltines, de nouvelles variétés de mûrier et des méthodes de culture adaptées à ces variétés. Comme le savent les experts rassemblés ici, pour un pays de la taille de l'Inde, où plus de 70 % de la population vit en zone rurale et où 35 % seulement de la population sait lire et écrire, l'un des moyens d'obtenir une croissance économique et le plein emploi est de développer les industries agricoles. La sériciculture est une industrie agricole comportant une période d'inactivité très réduite et un taux d'emploi élevé. Nous avons en Inde instauré un système qui donne suffisamment de liberté d'action aux entreprises privées pour la production. Des coopératives interviennent au niveau des prestations de service et de la commercialisation. Le Gouvernement intervient pour fournir l'infrastructure de base qui demande de gros investissements. Notre système est une association judicieuse de l'entreprise individuelle, des coopératives et du Gouvernement.

Outre les progrès obtenus pour la sériciculture mûrier, l'Inde a aussi fait de grands progrès en ce qui concerne la soie tassar. Alors que l'élevage du tassar s'effectuait traditionnellement dans les régions boisées existantes, les résultats des recherches de notre Institut du Tassar nous permettent désormais d'entreprendre des plantations de la plante nourricière, ce qui a permis de transformer les jachères en terrains cultivés, de réaliser des objectifs forestiers, d'augmenter le niveau de vie des populations. En ce qui concerne les vers à soie Eri et Muga, nos scientifiques sont en train de mener des recherches pour accroître l'importance du ver à soie Eri dans notre pays et relever la production de la soie Muga à son niveau initial.

La sériciculture en Inde est une expérience passionnante. Ses implications sont considérables pour l'amélioration de la vie des paysans pauvres. Nous avons aujourd'hui plus de vingt mille personnes (scientifiques, fonctionnaires administratifs, techniciens) qui travaillent au développement de la sériciculture, d'un bout à l'autre du pays. L'Inde est le seul pays qui exploite aujourd'hui les quatre sortes soie connues sur le marché. C'est ici également qu'a été annoncé le passage de la sériciculture des zones tempérées aux zones tropicales.

Encore une fois, je vous souhaite la bienvenue et espère que les débats de ce Congrès permettront d'atteindre une vie meilleure de par le monde, grâce à la sériciculture.

Je prie Madame le Ministre de la Sériciculture du Gouvernement du Karnataka de bien vouloir inaugurer le Congrès.

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## INAUGURAL ADDRESS

Delivered by

the Honourable Minister for Sericulture and Social Welfare

Smt. CHANDRAPRABHA URS

Sri B. Sivaraman, the President of the XIV International Congress; Sri H. Bouvier, Secretary-General of the International Sericultural Commission; Sri R. Currie, General Secretary of the International Silk Association; Sri J.C. Lynn, Chairman of the Steering Committee of this Congress; Sri A.P. Bhatikar, Secretary of the Central Silk Board; Distinguished Delegates; Ladies and Gentlemen;

May I at the outset thank the Chairman, Central Silk Board and the President of this Congress and all members of the International Sericulture Congress at the honour done to me by allowing me to participate in this function. Let me also on behalf of the Government of Karnataka welcome you all to our City and the XIV International Silk Congress.

We are all aware of the universal fascination for silk as a clothing material. Its softness and its beauty in different colours makes it a very attractive and comfortable wearing material. Its very special sheen and ability to accept colours in various shades makes it a material ideally suited for all occasions. It is thus, that in the history of clothing industry, silk has had and will continue to have a unique place rarely challenged by any other fabric or material. Silk has been known in India since ancient times. It finds mention in the Mahabharata as one of the array of luxury items brought to the courts of the Pandavas after their conquest of the world. It is quite certain that by the Mauryan period (4th to 2nd centuries B.C.) there was a considerable trade in Chinese Silk and according to Basham the famous historian, a few centuries later India's

*"spinners and weavers could produce semi-transparent silks and muslins of extreme thinness which are clearly depicted in sculpture and which were much in demand in the Roman Empire".*

Fabrics, raw silk and cocoons since the early ages have been articles of commerce. Wild silks have been produced in India since time immemorial. "Tassar", "Muga" and "Eri" are quite indigenous to the Indian sub-continent which are concentrated through out the forested and hilly regions of India and may well have been widespread earlier. They have been reeled and woven for a long time and quite sometimes woven locally to provide a kind of coarse silk cloth for the local villages. The early Indian silks, quite possibly were derived from these wild silks rather than the mulberry silkworm. However, as far as mulberry silkworm is concerned there have been in modern times certain races which have been recorded as indigenous to both Bengal and Mysore. The latter tract has a race known as the Pure Mysore Race which is considered very much an indigenous variety.

India is now poised to enter the international market in a big way. Though it still trails behind the two giants China and Japan, it has nevertheless kept up with expansion and has emerged as the third largest sericultural nation in the world. India now supplies the bulk of its own requirements, in addition to export of small quantities of fabrics and silk waste. Though the ancient Bengal silk industry is now making efforts to regain its earlier position, the present pattern of sericultural development in the country has been altogether different. It is the State of Karnataka which has in the meanwhile dominated the national scene. There is currently a tremendous expansion programme for sericulture in Karnataka and for many more years to come Karnataka will continue to produce at least 65 per cent of India's mulberry silk.

The modern silk industry in India has grown to meet the domestic rather than export requirements and this is a fact of great importance for the industry. Like Japan, India has a culture in which silk occupies a dominant position. Silk is the symbol of purity, luxury and prestige for all ceremony and ritual. It is an integral part of the customs and tradition of the people. It is the prevailing custom of female clothing. It is indeed a material which is a must for all classes of people for a variety of social ceremonial and ritual occasions.

For the women of the upper class silk is essentially the only proper dress for all occasions and for all kinds of formal social functions. Even the ladies of the middle class are fully conversant with the style and characteristics of saris of the major weaving centres of Varanasi, Kanjeevaram, Kumbakonam, Mysore and so on. On a major social occasion such as a wedding, silk achieves its widest use and its predominant position as an apparel. The marriage season therefore has considerable influence on the silk market. The bride is expected to be given a trousseau of silk saris. The men and women who attend the wedding all want to wear silk. The bridegroom likewise is expected to be suitably adorned in silk to suit the occasion. Silk is used to decorate Temple Chariots at festivals and is compulsory wearing for the priestly class on religious occasions.

In the global context however, silk accounts for less than 0.2 per cent of the total world production of textile fibres. It is interesting however to note that despite the enormous increase in the production of man made fibres in recent years, global silk production is growing steadily. A study of the trends in world production of cocoons and raw silk strongly brings out the fact that there has been a drastic fall in the production of silk in Japan. The Republic of Korea which has emerged as a major producer of raw silk during the 1970s has also shown a declining trend in recent years. Her production of raw silk which was at the level of 5,510 in 1977 came down to 2,520 in 1981 showing a drastic reduction of more than 50 per cent. Japan is trying its best to sustain its own sericulture industry which has been declining fast in recent years and to do so she has been exercising monopoly control on imports of raw silk and silk products and the silk prices in the domestic market have been maintained at a far higher level than the Chinese raw silk prices so as to sustain

the local sericultural industry.

In China, the production of raw silk rose to 26,000 tonnes in 1981 from that of 15,500 tonnes in 1977. Out of the estimated total of 26,000 tonnes it has exported about 10,362 tonnes.

Even while the demand for raw silk is expanding, production in the temperate countries is shrinking due to high labour costs. It is in China, India and Brazil that production is growing and expanding. Thus whereas China, the Republic of Korea and Brazil have sizeable marketable surpluses, Japan imported 50 per cent or more than its production and like Japan, India's total consumption is more than its production. In spite of this India exports about 10 per cent of the domestic production.

The average rate of growth in the production of raw silk in India has been in the order of 6.2 per cent per annum which includes both mulberry raw silk and non mulberry raw silk. The average rate of growth for mulberry raw silk is about 8.1 per cent per annum. In so far as Karnataka is concerned, which is the most dominant mulberry silk producing State, its average growth rate per annum has been in the order of 7.2 per cent reaching nearly 3200 tones of raw silk as at the end of 1982-83. States like Andhra Pradesh and West Bengal have shown extremely rapid progress in their growth rate averaging 10.4 and 10.5 per cent per annum. Karnataka has been implementing a major project for sericultural development with financial assistance from the World Bank at a cost of Rs.800 millions during the current plan period which aims at doubling the production of raw silk in the State to the level of 4,500 MT including 1000 MT of bivoltine raw silk at the end of 1984-85. Against the production target of 3400 MT of raw silk for the year 1983-84 we had achieved the production level of 3920 MT of raw silk including only about 144 MT of bivoltine raw silk. Production of bivoltine raw silk has remained low and we have fallen short of the target for 1983-84. One of the main reason has been the lack of demand from the consuming centres for bivoltine raw silk. The low demand is probably because of the availability of cheap imported raw silk in the market. Efforts are however under way to increase the production during the remaining period of the plan to achieve the projected targets. Such measures include a combination of incentives to the rearers and reelers as also in the field of research and development of superior bivoltine silkworm races and the management of seed multiplication centres at the P3 and P2 levels. In so far as the effect of diseases and pest on silk production is concerned the efforts of the various research institutes and universities has been commendable. Crop losses due to the menace of Uzi fly have been minimised. Further research efforts on evolving long term control measures are in progress.

In India the bulk of the silk goods now produced are still in the decentralised handloom sector. It is only in recent years that efforts have been made to take up silk weaving in a large scale in powerlooms. As a result of this, a large number of powerlooms has come into existence. This has possibly been triggered off by a rising demand of silk goods in urban areas and partly due to a rising trend in exports.

Nevertheless, the products of textiles and fabrics in our country have still to depend upon the traditional middlemen, most of whom have no stake in the industry. The traditional pattern of marketing continues to prevail. But we have realised the fact that the function of selling of silk goods and fabrics should be modernised and converted into a function of marketing which should be in tune with the changes in consumer tastes, fashions and preferences. The traditional seller oriented situation will have to be consciously changed into a consumer oriented phenomenon which is very much the situation in the other textile sectors.

An analysis of the domestic Indian market reveals that the products meant for the traditional local markets are items of sarrees, blouse pieces and traditional

female garments of India. In such a situation, this product-mix of sarees and blouse pieces is facing stiff competition from similar goods from the synthetic and man-made fabric sector. If the expanding market for fibre and textiles is to be adequately supported by silk textiles we would consciously have to plan for the marketing of silk textiles in such fashions and in such a manner as would tend to satisfy consumer tastes.

A sustained effort for promotion of quality silk goods in the domestic market would be required as it would be required for the export market too. It is also assumed that the local market share for silk goods in the rural areas will have to be expanded.

Export of Indian silk forms only about 0.8 per cent of the country's total exports. Mulberry and Tassar silk goods account for a major share of silk exports. Silk waste is another item that has found export avenues but is subject to wild fluctuations. Mulberry silk goods however still remain the major item of export and account for nearly 80-85 per cent of the total exports followed by tassar and tassar mixed silk goods. Currently India's exports earnings of the industry are about Rs.850 millions per annum with a steady and rising trend. Sarees, scarves, dress materials, carpets, finished garments and other made-ups like ties, cushion covers, etc, form the variety of products of the mulberry silk goods which finds a ready market abroad. Amongst the tassar goods, dress materials, furnishings are the main item of exports. Dress materials appear to have maintained steady growth accounting for about 40 per cent of the exports at current levels. In recent years sarees are the other item which have shown a steady upward trend. However, certain other non-traditional items like cushion covers, pillow covers, wall hangings, etc, have been of late showing a positive growth rate. The direction of exports has been mainly to the Western Europe markets followed by United States of America and Canada. Although Western European countries are our important buyers their markets have not been fully and adequately exploited. The distinguished delegates to this convention and the International Sericultural Commission may give some thought to the question of international cooperation in this sphere of international marketing and development of markets. The silk producing nations may cooperate to devise ways and means of developing and promoting silk consumption without detriment to each others interests. Even at the present juncture no ready data on the global demand for silk is available and neither is data available for the demand of different varieties, grades and products of silk. The Commission may think in terms of making available to all member countries readily available data on the global patterns of demand and consumption which would help member countries to expand their trade and production of raw silk and silk goods.

The strengthening of the data base on silk and silk goods, its production and consumption is a subject which ought not to pose many problems. It is only a matter of cooperation between member countries. The advantage of a ready and reliable source of international statistics is too well known, for me to reiterate the matter for the Commission. The data would make easier the task of the producing countries to plan and gear up their production to international requirements and would generally benefit all of us, the producer nations as well as the consuming nations.

While on the subject of international cooperation on such matters, I thought I should also draw the attention of the distinguished delegates to the exchange of up-to-date knowledge and technology in matters concerning all these aspects which go into increased production of silk in cultivation of mulberry, rearing of silk-worms, reeling of cocoons, processing of raw silk and the finishing of silk goods. In our State, as I had mentioned earlier, we have a World Bank promoted project on Sericulture costing Rs.800 million. Our scientists and technicians have done commendable work to raise production and productivity. But much remains to be done as yet.

Some of our lesser achievements can be ascribed to low level techniques, technology and the lack of robust and hardy races of worms fully adapted to tropical conditions. It is such a context that I am requesting the Commission to give some thought to international exchange of knowledge and technology. The Commission may consider how best the latest technologies can be transferred and exchanged between member nations.

Natural fibres such as cotton and silk will continue to play their role in the world consumption of textiles. Silk cannot be and will not be displaced from its premier position as the "Queen of Textiles". It is in the interest of the Commission and all member nations, that the inherent productivity and production of producing nations like ours, is enhanced through improved levels of techniques. This will require the exchange of knowledge and transfer of technologies between nations. And in this, the role of the International Sericultural Commission is significant.

Having regard to the massive outlays and intensive Sericultural Development Programmes initiated, the generation of technical manpower plays a vital role. The success of our programmes in sericulture requires considerable intensification of our manpower training and human resources development. Although we have made commendable progress in this regard, in the short run, high level training in the latest methods and technologies through international cooperation is extremely essential especially in silk reeling and processing. I would commend this course of action to be considered by the Commission and devise ways and means of appropriate training with various aspects of the silk industry.

Having said all this, I would only like to mention one word about the word "SILK". We all know silk and silk fabrics are something very special. Like a rare wine, silk is a very prized possession. The word silk should not therefore be misused or abused. There is much reason as to why both the word and the product should be protected jealously. In recent times there have been many claims that certain fabrics are "pure silk" although they are not so. Many have been using such words as "Silk Polyester". Certain other kinds of man-made fabrics are being compared to silk and are claimed to be silk itself. Apparently there are no international standards or markings like the "Wool Mark" to protect the natural silk as against spurious claims made on behalf of man-made artificial fibres. There are no protocols or rules regarding the comparison of one fibre against another. It is important that silk be protected against the onslaughts of such gross abuse. It should not only be promoted but fully guarded against such actions. As to how this should be done and what kind of markings or certification procedures should be evolved and strictly enforced may suitably be considered by the Commission. The financial costs of such schemes is negligible but the gains to the industry in general and the producing and consumer nations in particular is tremendous.

I would now thank the President of this Convention, the President and Members of the International Sericultural Commission, the Government of India, the Central Silk Board and all the distinguished delegates for having afforded me an opportunity in participating in this convention. It is indeed a great privilege and honour to have all of you here in Bangalore and I have the utmost pleasure in inaugurating this conference. I am quite sure that your deliberations during the next few days will be fruitful and assist all member nations and all others connected with the industry in expanding and sustaining the industry with vigour.

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Traduction Résumée  
du  
DISCOURS D'INAUGURATION  
prononcé par  
Smt CHANDRAPRABHA URS  
Ministre de la Sériciculture et des Affaires Sociales

Monsieur B. Sivaraman, Président du XIVème Congrès International, Monsieur H. Bouvier, Secrétaire Général de la Commission Séricicole Internationale, Monsieur R. Currie, Secrétaire Général de l'Association Internationale de la Soie, Monsieur J.C. Lynn, Président du Comité d'Organisation de ce Congrès, Monsieur A.P. Bhatikar, Secrétaire Général du Central Silk Board, Messieurs les Délégués, Mesdames et Messieurs,

Je voudrais d'abord remercier le Président du Central Silk Board, Président de ce Congrès, et tous les participants à ce Congrès Séricicole International, de l'honneur qui m'a été fait, en m'invitant à présider cette cérémonie. Au nom du Gouvernement du Karnataka, je vous souhaite la bienvenue à tous dans notre Cité et au XIVème Congrès Séricicole International.

Nous connaissons tous la fascination universelle exercée par la soie. Sa douceur et la beauté de ses différents coloris en font un tissu confortable et agréable à porter. La soie est connue en Inde depuis des temps très anciens. Il en est fait mention dans le Mahabharata comme d'une parure luxueuse apportée à la cour des Pandavas après leur conquête du Monde. Il est presque certain qu'un commerce important de soie chinoise existait pendant la période allant du IVème au IIème siècle avant J.C. Selon le célèbre historien Basham, quelques siècles plus tard en Inde,

*"Les filateurs et tisserands fabriquaient des soies semi-transparentes et des mousselines d'une extrême finesse, représentées sur les sculptures, qui étaient très recherchées dans l'Empire Romain".*

La production des soies sauvages existe en Inde depuis la nuit des temps. Les vers à soie "tassar", "muga" et "eri" sont sûrement originaires du sous-continent indien, car on les trouve dans toutes les parties boisées et montagneuses de l'Inde. Aujourd'hui, certaines races de ver à soie du mûrier sont considérées comme originaires du Bengale et de Mysore. La région de Mysore possède une race connue sous le

nom de Pure Mysore.

L'Inde est maintenant en mesure de tenir une grande place sur le marché international. Bien qu'elle reste derrière les deux géants, la Chine et le Japon, elle a néanmoins pris la troisième place parmi les nations séricicoles du monde.

Un important programme de développement de la sériciculture est actuellement en cours au Karnataka. Le Karnataka est l'état qui domine actuellement la scène nationale et produit 65 pour cent de la soie mûrier en Inde.

L'industrie de la soie dans l'Inde d'aujourd'hui satisfait plutôt le marché intérieur que l'exportation, et ceci est très important. Comme le Japon, l'Inde a une civilisation dans laquelle la soie occupe une place importante. La soie est un symbole de pureté, de luxe et de prestige dans tous les rites et les cérémonies.

Pour les femmes de la haute société, la soie est la seule manière de s'habiller en toutes occasions. Dans toutes les cérémonies importantes, les mariages par exemple, la soie est utilisée largement en tant que parure. Toutes les personnes invitées à un mariage veulent porter de la soie. La soie est utilisée pour décorer les chars religieux lors des fêtes et son port est obligatoire pour les prêtres lors des cérémonies religieuses.

Dans le contexte général cependant, la soie ne représente que 0,2 pour cent de la production textile mondiale. Il est intéressant de noter que malgré l'essor considérable de la production de fibres synthétiques au cours des dernières années, la production globale de soie augmente régulièrement. L'étude de l'évolution de la production mondiale de cocons et de soie grège met en évidence une forte baisse de production au Japon. La République de Corée qui était parmi les pays gros producteurs au cours des années 70, montre également une tendance à la baisse au cours de ces dernières années. Le Japon fait de son mieux pour soutenir son industrie séricicole en contrôlant les importations de soie grège et d'articles en soie et en maintenant le prix de la soie sur le marché intérieur à un niveau bien supérieur à celui du prix chinois.

En Chine, la production de soie grège est passée de 15 500 tonnes en 1977 à 26 000 tonnes en 1981. Ses exportations en 1981 ont atteint 10 362 tonnes.

Alors que la demande de soie grège augmente, la production des pays tempérés industrialisés diminue en raison du coût élevé de la main d'oeuvre. En Chine, en Inde et au Brésil, la production s'accroît.

Le taux moyen de croissance de la production de soie grège en Inde est de l'ordre de 6,2 pour cent par an, soie mûrier et soie non-mûrier confondues. Le taux moyen de croissance de la soie grège mûrier est d'environ 8,1 pour cent par an. En ce qui concerne le Karnataka, principal Etat producteur de soie mûrier, le taux de croissance par an est de l'ordre de 7,2 pour cent : la production de soie grège a été de 3 200 tonnes à la fin de 1982-83. Des Etats comme l'Andhra Pradesh ou le Bengale Occidental font des progrès extrêmement rapides, leur taux de croissance étant en moyenne de 10,4 et 10,5 par an. Le Karnataka a lancé un projet important en faveur du développement de la sériciculture qui bénéficie de l'aide financière de la Banque Mondiale à concurrence de 800 millions de Roupies. Ce programme a pour but de doubler la production de soie grège de l'Etat pour atteindre 4 500 tonnes (dont 1 000 tonnes de soie grège bivoltine) à la fin de 1984-85.

Les efforts déployés par les divers instituts de recherche et les universités dans la lutte contre les maladies et les parasites sont dignes d'éloge. Les dégâts provoqués par la mouche ouzy ont été réduits. D'autres recherches sont en cours pour

mettre au point des méthodes de prévention à long terme.

En Inde, la majeure partie des articles en soie provient du secteur artisanal décentralisé des métiers à bras. Ce n'est qu'au cours de ces dernières années que des efforts ont été faits pour développer le tissage de la soie sur les métiers mécaniques.

L'analyse du marché intérieur indien révèle que les produits destinés aux marchés locaux traditionnels sont les saris, les chemisiers et les vêtements féminins traditionnels. Un effort soutenu serait nécessaire pour promouvoir les articles de soie de qualité sur le marché national comme à l'exportation.

Les exportations de soie indienne ne représentent que 0,8 pour cent environ du total des exportations du pays. Les articles de soie mûrier et tassar en forment la plus grande partie. Les déchets de soie ont un bon débouché à l'exportation mais sont sujets à d'importantes fluctuations des cours.

Actuellement, les exportations s'élèvent à 850 millions de Roupies par an avec une régulière tendance à la progression.

Les exportations s'effectuent principalement en direction de l'Europe de l'Ouest, des Etats Unis d'Amérique et du Canada. Bien que les pays européens nous achètent beaucoup, leurs marchés n'ont pas été exploités complètement et de manière adéquate. Les délégués de cette assemblée et la Commission Séricicole Internationale devraient réfléchir à la question de la coopération internationale dans ce domaine. Les pays producteurs de soie devraient collaborer pour décider des moyens et de la manière de développer et promouvoir la consommation de la soie, en respectant les intérêts de chacun. Même à présent, on ne peut obtenir de données sur la demande globale de soie, ni sur la demande pour chacun des différents produits soyeux. La Commission devrait étudier la possibilité de fournir aux Etats Membres des données générales sur l'évolution de la consommation et la demande de soie. Ceci serait fort utile aux Etats Membres pour développer leur production et leur marché pour la soie grège et les articles de soie.

L'établissement de statistiques sur la soie et les soieries (consommation et production) ne devrait pas poser beaucoup de problèmes. C'est simplement une affaire de collaboration entre les pays membres. Une source de données statistiques internationales rendrait la tâche plus facile aux pays producteurs pour déterminer et gérer leur production en fonction des besoins internationaux et serait bénéfique à tous.

Je voudrais également attirer l'attention des délégués sur le transfert des connaissances et de la technologie en ce qui concerne tous les aspects visant à améliorer la production de la soie : culture du mûrier, élevage des vers à soie, filature des cocons, transformation de la soie grège et finition des produits. Nos chercheurs et techniciens ont accompli un travail remarquable pour améliorer la production et la productivité. Mais beaucoup reste encore à faire. Certains de nos échecs peuvent être attribués au faible niveau technique et au manque de races de vers à soie robustes complètement adaptées aux conditions tropicales. C'est dans cet esprit que je demande à la Commission de bien vouloir se pencher sur la question de l'échange international des connaissances et technologies. La Commission pourrait étudier la meilleure manière de transférer et échanger les techniques les plus récentes entre les pays membres.

La soie ne peut pas et ne doit pas perdre son titre de "Reine des Textiles". Il en va de l'intérêt de la Commission et de tous les Etats Membres que la productivité des pays producteurs comme les nôtres, soit améliorée par de meilleures techniques. Cela nécessite l'échange des connaissances et le transfert des technologies

entre les pays. Et en cela, le rôle de la Commission est de première importance.

La formation de haut niveau aux méthodes et technologies les plus récentes, au moyen de la coopération internationale est essentielle, particulièrement pour la filature et la transformation de la soie. Je voudrais insister auprès de la Commission pour qu'elle prenne en considération ce type d'action et définisse les possibilités de formation dans divers aspects de l'industrie de la soie.

Enfin, je voudrais simplement dire un mot au sujet du mot "SOIE". Le mot soie ne devrait pas être employé de façon abusive. Certains types de tissus synthétiques sont comparés à la soie et sont présentés comme étant de la soie. Il n'existe apparemment pas de standards internationaux ou de marques telles que la "Woolmark" pour protéger la soie naturelle contre les fausses appellations faites pour des fibres artificielles de synthèse.

Je voudrais maintenant remercier le Président du Congrès, le Président et les Membres de la Commission Séricicole Internationale, le Gouvernement indien, le Central Silk Board et tous les délégués, pour m'avoir permis de participer à ce congrès. C'est pour moi un grand privilège et honneur de vous accueillir ici à Bangalore et j'ai le plus grand plaisir à inaugurer ce congrès. Je suis sûre que vos débats des prochains jours seront fructueux et aideront tous les Etats Membres et tous les autres pays séricicoles à améliorer et renforcer l'industrie de la soie.

\* \* \*

**REMISE DU PRIX PASTEUR  
AWARDING OF PASTEUR PRIZE**

The Honourable Minister for Sericulture Smt Chandrababha Urs remitted the 1983 Pasteur Prize medal and diploma to:

Mr. Yasuhisa MANO (Japan), for Dr Yataro TAZIMA and himself,  
awarded for their works on the breeding of autosexing races of silkworm and its application to sericulture;

Prof. Jean-Marie LEGAY (France) for his works on the utilization of the silkworm as a biological model for basic research.

Smt Chandrababha Urs, Ministre de la Sériciculture, a remis les médailles et diplômes du Prix Pasteur 1983 à :

Monsieur Yasuhisa MANO (Japon) pour le Dr Yataro TAZIMA et pour lui même, prix attribué pour leurs travaux sur les races autosexables de ver à soie et leur application en sériciculture ;

M. le Professeur Jean-Marie LEGAY (France) pour ses travaux qui ont introduit le ver à soie dans les laboratoires et fait de celui-ci un modèle biologique pour la recherche fondamentale.

## REPONSE ET REMERCIEMENTS

du

Docteur Henri BOUVIER,

Secrétaire Général de la Commission Séricicole Internationale

Madame le Ministre,

Vous venez d'indiquer les raisons qui font de la soie la Reine des Textiles. Vous avez exposé la situation de la production séricicole dans le monde et parlé de l'évolution de la sériciculture en Inde.

Après votre allocution et celle de Monsieur le Président du Central Silk Board, je n'ai plus rien à dire, sauf remercier en mon nom personnel, au nom de la Commission Séricicole Internationale et de tous les participants ici présents, le Gouvernement indien pour avoir bien voulu organiser, à Bangalore, le XIVème Congrès Séricicole International.

C'est la première fois qu'un tel congrès se tient hors du bassin méditerranéen. Les premiers congrès séricicoles internationaux se sont tenus en Italie et en France entre 1870 et 1878. Il s'agissait alors de vulgariser les méthodes de lutte contre la pébrine, cette maladie du ver à soie qui avait fait son apparition en France en 1853 et s'était propagée dans le monde entier.

Le VIIème Congrès Séricicole a eu lieu à Alès en 1948 alors que la deuxième guerre mondiale venait de prendre fin et qu'étaient apparues les fibres synthétiques. On pouvait alors se demander si la soie avait encore un avenir. La réponse ayant été positive, c'est à la suite de ce congrès qu'a été décidée la création de la Commission Séricicole Internationale. Les congrès qui suivirent avaient pour objet une meilleure connaissance biologique du ver à soie, un accroissement de la productivité et l'industrialisation des élevages.

Le sujet de ce congrès particulièrement important, comporte l'étude des problèmes de la sériciculture dans les pays des régions tropicales. C'est vers ces pays en effet que va se déplacer, dans un avenir plus ou moins proche, la production de la soie, production qui sera pour ces régions un facteur de développement, et procurera à des populations souvent très déshéritées, les revenus monétaires qui leur manquent.

C'est cet aspect humain qui justifie votre présence, Madame le Ministre, et l'importance des participations de l'Inde, de treize pays et de trois organisations internationales.

Je vous remercie, Madame le Ministre, Monsieur le Président du Central Silk Board, de présider cette réunion inaugurale.

Je vous demande de transmettre mes remerciements au Gouvernement indien et au Gouvernement de Karnataka.

Je rends hommage aux dirigeants du Central Silk Board et en particulier à son Secrétaire Général, Monsieur Bhatikar, qui a assuré d'une manière parfaite l'organisation de ce congrès.

J'y associe tous ceux qui, chacun à leur niveau, ont contribué à cette réalisation.

\* \* \*

## ANSWER AND THANKS

by

Secretary General of the International Sericultural Commission

Dr. H. BOUVIER

Honourable Minister,

You have just stressed the reasons why silk is the Queen of Textiles. You have shown the situation of silk production in the world and spoken of the evolution of sericulture in India.

Further to your address and the speech of the President of the Central Silk Board, I have nothing more to say but thank, on my behalf, on behalf of the International Sericultural Commission and all participants present here, the Indian Government for having organized in Bangalore the XIV International Sericultural Congress.

This is the first time that such a convention takes place beyond the Mediterranean basin. The first international sericultural congresses were held in Italy and in France between 1870 and 1878. They were aimed to propagate the methods of control of the pebrine, that silkworm disease which occurred in France in 1853 and spread all over the world.

The VII Sericultural Congress took place in Alès (France) in 1948. At that time, the World War II had just ended and the man-made fibres had appeared. The question was to be raised whether silk still had a future. The positive answer given at this congress resulted in the founding of the International Sericultural Commission. The following congresses dealt with the improvement of knowledge on silkworm biology, the increase in productivity and the industrialisation of rearing methods.

This congress has a special importance as it is devoted to the study of problems bound to sericulture in tropical countries. These countries will sooner or later become the main area of silk production. This production will be a factor of development for these regions and will give to underprivileged populations the monetary income they are in need of.

It is this social aspect that confers their full meaning to your presence, Honourable Minister, and to the importance of participation from India, thirteen countries and three international organizations.

Honourable Minister, Mr. President of the Central Silk Board, I thank you for presiding over this inaugural meeting.

I beg you to convey my thanks to the Indian Government and to the Government of Karnataka.

I render homage to the Central Silk Board executives, and especially to Secretary General Mr Bhatikar who ensured the organizing of the congress perfectly.

I associate to this homage every one who, at one's own level, contributed to this realization.

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XIVe CONGRES SERICICOLE INTERNATIONAL  
XIVth INTERNATIONAL SERICULTURAL CONGRESS

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SECTION MORIER  
MULBERRY SECTION

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Chairmen : K. HAZAMA  
S. ISHIKAWA

# MULBERRY SECTION / SECTION MURIER

- R. THIANGAMANI and M. VIVEKANANDAN  
Physiological studies and leaf nutrient analysis in the evaluation of best mulberry variety. (*Etudes physiologiques et analyses des composants nutritifs de la feuille pour la détermination de la meilleure variété de mûrier*). 317
- M.P. SHREE  
Control of mulberry stem canker disease cause by Botryodiplodia theobromae pat. (*Contrôle du chancre de la tige du mûrier provoqué par Botryodiplodia theobromae pat.*). 325
- C.R. SASTRY  
Mulberry varieties, exploitation and pathology. (*Variétés de mûrier, exploitation et pathologie*). 333
- D.S. TAYADE and M.D. JAWALE  
Studies on the comparative performance of silkworm races against different varieties of mulberry under Marathwada conditions. (*Etudes comparatives des performances des races de vers à soie élevées dans les conditions de Marathwada avec différentes variétés de mûrier*). 361
- S.N. NARAYANA COWDA and G. BORATIAH  
Preliminary studies on the taxonomy of Indian mulberry varieties. (*Etudes préliminaires sur la taxonomie des variétés indiennes de mûrier*). 365
- S. SHAMA RAO  
Air-spores of mulberry farms in Bangalore. (*Spores dans l'atmosphère des plantations de mûriers à Bangalore*). 367
- B.C. DAS  
Mulberry varieties, exploitation and pathology. (*Variétés de mûrier, exploitation et pathologie*). 369
- S.B. SULLIA and S.D. PADMA  
Utilisation of different carbon sources by a new isolate of Myrothecium causing leaf spot of mulberry. (*Utilisation de différentes sources de carbone par un nouvel isolat de Myrothecium provoquant des tâches sur les feuilles de mûrier*). 370
- P.L. PREMI  
Insects and mites pest-complex of mulberry in India. (*Complexe parasitaire, insecte-punaie, du mûrier en Inde*). 372
- G. RAVI KUMAR  
Preliminary studies on the evaluation of new promising indigenous strains of mulberry. (*Etudes préliminaires sur l'évaluation de nouvelles souches indigènes de mûrier*). 373

## PHYSIOLOGICAL STUDIES AND LEAF NUTRIENT ANALYSIS IN THE EVALUATION OF BEST MULBERRY VARIETY

### ETUDES PHYSIOLOGIQUES ET ANALYSES DES COMPOSANTS NUTRITIFS DE LA FEUILLE POUR LA DETERMINATION DE LA MEILLEURE VARIETE DE MURIER

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India.

In Tamilnadu,  $M_5$  variety of mulberry, apart from Berhampur local variety, is widely cultivated by sericulturists. To find out whether a better variety can be evolved, cuttings of seven different varieties viz.,  $S_{54}$ ,  $C_1$ ,  $MR_2$ , Kitchili, Roso, Kosen and Japan were brought from the Tamilnadu Government's mulberry farm, Coonoor, and planted in the plains of Tamilnadu (Tiruchirappalli). Only 25 % of the cuttings sprouted initially, but the cuttings of those established under local climatic conditions exhibited 100 % sprouting, when replanted.

The results of biochemical analyses and feeding trial experiments revealed that, of all varieties tested,  $MR_2$  variety was found to be superior to others and also varieties like  $C_1$ ,  $S_{54}$  Roso and Kitchili were found to give better performance than the presently and widely cultivated  $M_5$  variety. The total content of chlorophyll is higher in both  $MR_2$  and Japan varieties, probably indicating that these two varieties were photosynthetically more efficient.

La variété de mûrier  $M_5$ , comme la variété locale Berhampur, est largement cultivée dans le Tamilnadu. Afin de trouver une variété de mûrier plus performante, des boutures de sept variétés différentes de mûrier ( $S_{54}$ ,  $C_1$ ,  $MR_2$ , Kitchili, Roso, Kosen et Japon) provenant de la plantation du gouvernement du Tamilnadu (Coonoor) ont été plantées dans les plaines du Tamilnadu (Tiruchirappalli). 25% seulement des boutures avaient des bourgeons, mais après repiquage, toutes les boutures soumises aux conditions climatiques locales ont bourgeonné. Les résultats des analyses biochimiques et des expériences sur l'alimentation montrent que, parmi toutes les variétés testées, la variété  $MR_2$  est la meilleure. Les variétés  $C_1$ ,  $S_{54}$ , Roso et Kitchili donnent également de meilleurs résultats que la variété  $M_5$ . La teneur en chlorophylle est supérieure dans les variétés  $MR_2$  et Japon, ce qui indique probablement que la photosynthèse est plus efficace chez ces deux races.

## INTRODUCTION

It is the primary aim of every sericulturist in Tamilnadu to get maximum leaf yield from the mulberry crop to maximise the cocoon production. Therefore, it becomes imperative to improve the nutritive value of mulberry leaf which influences the growth and development of silkworm. In recent years, a great deal of interest has been generated in the area of mulberry management with a view to increase the production of mulberry leaves. In view of this, recently, different varieties have been evolved using advanced techniques in plant breeding as well as methods like grafting etc., to increase the leaf yield. In Tamilnadu,  $M_5$  variety is most popularly grown as it is recommended to the sericulturists by the state government authorities. However, the leaf yield and the performance of the silkworm by feeding the  $M_5$  variety is not much encouraging and therefore, the present study has been undertaken to evolve a better variety of mulberry for Tamilnadu sericulturists.

Since mulberry leaves are the nutritive source for the silkworms, in our present study, eight different varieties viz.,  $S_{54}$ ,  $C_1$ ,  $MR_2$ , Kitchili, Roso, Kosen, Japan and  $M_5$  were taken for feeding trials and analysis of leaf nutrients to evolve a better mulberry variety, treating the  $M_5$  as the control.

## MATERIALS AND METHODS

Experiments were conducted in the university sericulture shed at  $30 \pm 1^\circ\text{C}$  with multivoltine cross breed L x KA variety. Cuttings of seven different varieties viz.,  $S_{54}$ ,  $C_1$ ,  $MR_2$ , Kitchili, Roso, Japan and Kosen brought from Tamilnadu Government's mulberry farm, Coonoor, and  $M_5$  variety from Uppiliapuram farm, Tiruchirappalli, were raised in the University botanic garden. Biochemical analyses of total soluble sugars, crude protein, total phenols, free amino acids, chloroplast pigments, total lipids, total ash as well as moisture content of mulberry leaves of all the eight varieties were carried out following standard procedures (Table 1.). For biochemical analysis leaves of different varieties of the same age and node were collected.

For feeding trial experiment, duplicate was conducted and separate disease free layings were used for each replication. Under identical conditions of temperature ( $30 \pm 1^\circ\text{C}$ ) and humidity (65-70 %) prevailing in Tamilnadu, the larvae were reared. The experiment was conducted in two different seasons. Feeding was given five times a day, each at an interval of about 4 hours with good quality leaves of different mulberry variety to each lot. Data were also collected in respect of average larval, cocoon and shell weight, silk ratio, effective rate of rearing and filament length.

## RESULTS

The cuttings of all the varieties brought from the Tamilnadu Government's mulberry farm, Coonoor, viz.,  $S_{54}$ ,  $C_1$ ,  $MR_2$ , Kosen, Roso, Kitchili and Japan, although sprouted only about 25 % initially, showed 100 % sprouting when cuttings of the plants established under Tiruchirappalli climatic conditions were replanted.

The biochemical composition of mulberry leaves of different varieties is given in Table 2. There was no difference in the moisture content of leaves of different varieties. The total soluble sugar content was marginally higher in Kitchili and Japan varieties followed by  $S_{54}$  and  $M_5$  varieties. There was no significant difference in the sugar content of  $C_1$ ,  $MR_2$  and Roso varieties. The total content of chlorophyll

was much higher in MR<sub>2</sub> and Japan varieties followed by Roso, C<sub>1</sub> and Kosen varieties (Table 3). There was no significant difference in the total chlorophyll content of M<sub>5</sub> and S<sub>54</sub>, and lowest level was observed in Kitchili. No significant difference was observed in the levels of carotenoids of MR<sub>2</sub>, Japan, Roso, Kosen, C<sub>1</sub> and S<sub>54</sub>, and in M<sub>5</sub> and Kitchili the carotenoid content was very much reduced.

The total protein content was uniform in all the varieties except in C<sub>1</sub> and MR<sub>2</sub> variety. MR<sub>2</sub> variety had the highest concentration of leaf protein compared to all the other varieties. There was significant difference in the level of free amino acids of S<sub>54</sub> and MR<sub>2</sub> varieties, whereas no such difference was observed in Kitchili, Roso and Japan. In C<sub>1</sub> and Kosen the free amino acid content was very low.

Regarding the content of total lipids highest concentration was observed in C<sub>1</sub> and Roso varieties followed by Kosen, MR<sub>2</sub>, Japan and M<sub>5</sub> and in S<sub>54</sub> and Kitchili lower values were obtained. Roso and S<sub>54</sub> has higher concentration of phenols compared to other varieties. The varieties C<sub>1</sub>, MR<sub>2</sub> and Kosen has a significant measure of ash content. Lowest content of ash was observed in S<sub>54</sub> and Japan varieties.

The effects of feeding trials of different varieties of mulberry on the growth of silkworm larvae and economic characters of cocoon are shown in Table 4. The average weight of mature larvae increased marginally in the feeding trials conducted on silkworm larvae by feeding mulberry leaves of MR<sub>2</sub>, Kosen, Kitchili and Japan varieties. There was no significant difference in the weight of single cocoon, single shell weight and in the percentage of silk ratio except in MR<sub>2</sub> and Japan varieties. The filament length increased to the level of significance as a result of Japan and MR<sub>2</sub> leaf feeding to the silkworm larvae. Most effective rate of rearing was obtained by feeding C<sub>1</sub>, MR<sub>2</sub>, S<sub>54</sub> and Kitchili leaf varieties. The percentage of effective rate of rearing was low by feeding of M<sub>5</sub> and Kosen varieties.

## DISCUSSION

The cuttings of all the seven varieties viz., Roso, Kosen, Japan, Kitchili, MR<sub>2</sub>, C<sub>1</sub> and S<sub>54</sub> showed 100 % sprouting once they got established under Tiruchirappalli climatic conditions.

From the biochemical analyses of mulberry leaves of different varieties (Table 2), it is discernable that in no single variety all the nutrients are present in the highest level. But from the silkworm nutrition point of view, leaf nutrients like total protein, free amino acids, total lipids and minerals are considered to be very important. Therefore, from nutrition point of view, varieties like MR<sub>2</sub> and C<sub>1</sub> are preferable followed by Kitchili and Roso for feeding silkworm larvae. From the total content of chlorophyll, it is probable that MR<sub>2</sub> and Japan varieties are photosynthetically more efficient, although this is to be confirmed by IRG studies in vivo.

In order to confirm the findings of biochemical analyses, feeding trials were also conducted with all the eight different varieties of mulberry leaves (Table 4). There was no significant difference in the cocoon and shell weight and percentage of silk ratio. However, significant difference was observed in the filament length and effective rate of rearing. From these two important parameters, it is quite evident that MR<sub>2</sub>, C<sub>1</sub>, S<sub>54</sub> Kitchili and Roso are most suitable varieties for silkworm rearing.

Feeding trials with silkworm larvae were also conducted by several workers to maximise the cocoon yield. Adbullaev (1961) reported a new variety that surpassed local variety in cocoon as well as raw silk yield. The superiority of Kanva-2 variety

over other varieties was reported by Takahashi (1961) which was later confirmed by Narayanan et al. (1966). Our finding that the MR<sub>2</sub> variety is superior in silkworm nutrition is further confirmed by a similar finding of Sironmani et al. (1983). From the experiment on feeding trials it is advocated that MR<sub>2</sub> that MR<sub>2</sub>, C<sub>1</sub>, S<sub>54</sub>, Kitchili and Roso are preferable in the order for silkworm rearing in Tamilnadu under Tiruchirappalli climatic conditions.

#### ACKNOWLEDGEMENT

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| Compounds            | Details                                              | Authors                |
|----------------------|------------------------------------------------------|------------------------|
| Total soluble sugars | Anthrone method                                      | Willis & Yemm (1954)   |
| Crude protein        | Micro-Kjeldahl method                                | Humphries (1956)       |
| Total phenols        | Modified Folin-Denis method                          | Swain & Hillis (1959)  |
| Free amino acids     | Ninhydrin method                                     | Lee & Takahashi (1966) |
| Total lipids         | Gravimetric method<br>Chloroform-Methanol<br>(3 : 1) | -----                  |
| Ash content          | Gravimetric method                                   | -----                  |
| Moisture             | Gravimetric method                                   | -----                  |
| Chloroplast pigments | Acetone extract                                      | Arnon (1949)           |

Table 1. Methods of analysis of different compounds.

| Variety         | Moisture (%) | Total soluble sugars | Crude protein | Free amino acids | Total phenols | Total lipids         | Total ash (Minerals) |
|-----------------|--------------|----------------------|---------------|------------------|---------------|----------------------|----------------------|
|                 |              |                      |               |                  |               | mg/gfw <sup>-1</sup> |                      |
| M <sub>5</sub>  | 67.44        | 11.33                | 24.35         | 0.374            | 1.186         | 24.3                 | 13.24                |
| S <sub>54</sub> | 67.59        | 12.88                | 22.16         | 0.583            | 1.494         | 17.3                 | 10.35                |
| C <sub>1</sub>  | 67.81        | 8.64                 | 27.55         | 0.190            | 1.026         | 53.8                 | 18.91                |
| MR <sub>2</sub> | 70.60        | 9.78                 | 29.46         | 0.557            | 1.086         | 35.0                 | 17.93                |
| Kitchili        | 68.84        | 15.08                | 22.89         | 0.283            | 1.164         | 13.8                 | 13.31                |
| Roso            | 68.38        | 8.94                 | 23.62         | 0.283            | 1.406         | 53.7                 | 14.36                |
| Japan           | 69.00        | 15.58                | 22.45         | 0.344            | 1.118         | 27.8                 | 11.16                |
| Kosen           | 63.67        | 9.84                 | 21.43         | 0.166            | 1.232         | 38.3                 | 15.90                |

Table 2. Biochemical composition of different varieties of mulberry leaves. The data are the average of three different experiments. (Data are expressed in g% on dry weight basis).

| Variety         | Chlorophyll a<br>mg gfw <sup>-1</sup> | Chlorophyll b<br>mg gfw <sup>-1</sup> | Chl, a/b<br>ratio | Carotenoid<br>mg gfw <sup>-1</sup> |
|-----------------|---------------------------------------|---------------------------------------|-------------------|------------------------------------|
| M <sub>5</sub>  | 0.669                                 | 0.338                                 | 1.9               | 0.293                              |
| C <sub>1</sub>  | 0.758                                 | 0.444                                 | 1.7               | 0.386                              |
| S <sub>54</sub> | 0.679                                 | 0.302                                 | 2.2               | 0.346                              |
| Kitchili        | 0.386                                 | 0.165                                 | 2.3               | 0.200                              |
| MR <sub>2</sub> | 0.903                                 | 0.488                                 | 1.8               | 0.390                              |
| Japan           | 0.861                                 | 0.473                                 | 1.8               | 0.360                              |
| Roso            | 0.783                                 | 0.356                                 | 2.2               | 0.328                              |
| Kosen           | 0.736                                 | 0.322                                 | 2.2               | 0.340                              |

Table 3. Chloroplast pigment composition of different varieties of mulberry leaves.

| Variety         | Weight of single<br>mature larva<br>before spinning<br>(g) | Weight of single<br>cocoon<br>(g) | Weight of single<br>shell<br>(g) | % of silk ratio | Filament length<br>(meters) | Effective rate<br>of rearing<br>(%) |
|-----------------|------------------------------------------------------------|-----------------------------------|----------------------------------|-----------------|-----------------------------|-------------------------------------|
|                 | mean value S.D.                                            | mean S.D.                         | mean S.D.                        | mean S.D.       |                             |                                     |
| M <sub>5</sub>  | 2.142 ± 0.07                                               | 1.172 ± 0.13                      | 0.189 ± 0.02                     | 16.19 ± 1.63    | 675                         | 74                                  |
| C <sub>1</sub>  | 2.040 ± 0.03                                               | 1.080 ± 0.08                      | 0.184 ± 0.01                     | 17.05 ± 1.73    | 710                         | 93                                  |
| Kitchili        | 2.344 ± 0.36                                               | 1.148 ± 0.12                      | 0.186 ± 0.02                     | 16.28 ± 2.18    | 625                         | 95                                  |
| S <sub>54</sub> | 1.964 ± 0.09                                               | 1.180 ± 0.15                      | 0.194 ± 0.02                     | 16.50 ± 0.80    | 735                         | 91                                  |
| Kosen           | 2.360 ± 0.05                                               | 1.293 ± 0.15                      | 0.216 ± 0.01                     | 16.84 ± 1.96    | 770                         | 71                                  |
| MR <sub>2</sub> | 2.280 ± 0.09                                               | 1.216 ± 0.11                      | 0.229 ± 0.01                     | 18.96 ± 1.68    | 900                         | 92                                  |
| Roso            | 2.190 ± 0.09                                               | 1.204 ± 0.11                      | 0.203 ± 0.01                     | 17.02 ± 2.02    | 770                         | 85                                  |
| Japan           | 2.450 ± 0.03                                               | 1.261 ± 0.10                      | 0.226 ± 0.01                     | 18.10 ± 1.77    | 800                         | 82                                  |

Table 4. Effects of mulberry leaf feeding of different varieties on the growth of silkworm larvae and economic characters of silk cocoons produced.  
The results are the average of two different experiments.

CONTROL OF MULBERRY STEM CANKER DISEASE CAUSED BY  
BOTRYODIPLODIA THEOBROMAE PAT.

CONTROLE DU CHANCRE DE LA TIGE DU MURIER PROVOQUE PAR  
BOTRYODIPLODIA THEOBROMAE PAT.

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*Efficacy of six fungicides of varied nature was tried in vitro and in vivo against the pathogen Botryodiplodia theobromae Pat. which causes stem canker disease of mulberry plants (Variety M5). Bavistin - a systemic fungicide - was found to be significantly superior to all other fungicides tried in inhibiting the growth of the fungus and thereby checking disease development. A soaking pre-treatment of mulberry stem cuttings in 10 ppm solution of Bavistin for 12 hours, before planting them in the field is suggested as a preventive measure.*

*L'efficacité de six fongicides contre le pathogène Botryodiplodia theobromae Pat. qui provoque la maladie du chancre de la tige du mûrier (variété M<sub>5</sub>) a été testée in vitro et in vivo. Le bavistin, un fongicide systémique, s'est avéré très nettement supérieur aux autres fongicides testés pour inhiber le développement du champignon et ainsi contrôler la progression de la maladie. Le traitement des boutures de mûrier par immersion dans une solution à 10 ppm de bavistin pendant 12 heures avant de les planter est considéré comme une mesure préventive.*

INTRODUCTION

During a survey of phytopathogenic fungi in the mulberry plantations of M5 variety in and around Bangalore, India, a severe infection of stems by Botryodiplodia theobromae Pat. (Padma Bai Luke and Sathiya Paul, 1982) was observed. The fungus seemed to be a facultative parasite. In the early stages of infection, greenish black

lesions were seen. Later, plenty of dark, black carbonaceous structures (pycnidial bodies) were produced in groups. Infection inhibited sprouting of mulberry stem cuttings. In certain stems which sprouted, infection remarkably retarded the growth. Disease incidence was 10 to 15% in mulberry stem cuttings which were pre-treated with ethyl methyl sulphonate and colchine (at a concentration of 0.5% and 1.0%) in a preliminary study of mutation breeding (Boraiah and Narayana Gowda, 1983). In this case, mutagens seem to have induced infection either by making the inoculum of the fungus turn pathogenic or by inducing proneness in the host plant. Since mulberry is mainly propagated through stem cuttings, it is necessary to check stem infection at an early stage itself. As there is no work on the control of this disease, an experiment was initiated to find out the effective fungicide to check this disease.

## MATERIALS AND METHODS

Efficacy of six fungicides of varied nature viz., Bavistin 50 (carbendazim (2-(Methoxy-carbomoyl)-benzimidazole), Blitox 50 (copper oxychloride), Captan (N-(trichloromethyl)thio/-4-cyclohexene-1, 2-dicarboximide), Dithane M-45 (a co-ordination product of Zinc ion and manganese ethylene bisdithiocarbamate), Dithane Z-78 (Zinc ethylene bisdithiocarbamate) and Karathane (Dinitro (1-methyl-heptyl) phenyl-crotonate and derivatives chiefly (1-methyl-heptyl) phenols commonly known as "Dinocap", as liquid concentrate) was tried against the incitant of mulberry stem canker disease.

### a) In vitro toxicity of fungicides :

The antifungal activity of these fungicides was tested by using a slightly modified poisoned food technique (Kothari and Bhatnagar, 1966). Known quantity of each fungicide based on its active ingredient was carefully incorporated to each flask containing 100ml of autoclaved potato-dextrose-agar (PDA) medium at 45°C keeping in view the final concentration to be prepared. Concentration of all the fungicides tried ranged within 50 ppm to 500 ppm. The incorporated medium after thorough mixing was plated in 9 cm diameter Petriplates for each concentration of the fungicide. PDA without the fungicide served as control. After allowing the plates to solidify, 0.4cm diameter inoculum discs cut from the margin of an actively growing culture of *B. theobromae* was transferred to the centre. The Petriplates were then incubated for seven days at laboratory temperature ( $26^{\circ} \pm 2^{\circ}\text{C}$ ). Effect of each fungicide was assessed by recording the average radial growth of the fungal colony at different concentrations.

### b) In vivo effect of the fungicide :

To find out the *in vivo* efficacy of Bavistin, mulberry stem cuttings of variety M5 were soaked in 10 ppm solution for 12 hours, dried in the shade for 2 to 3 hours and then planted in the field. They were sprayed with a spore-cum-mycelial suspension of the fungus *B. theobromae* (10,500 spores/ml) using an atomiser. Another set of stem cuttings were pre-treated with the fungus suspension for 12 hours, dried in the shade and planted in the field. They were then sprayed with 10 ppm solution of Bavistin. Control was maintained by planting stem cuttings soaked in fungus solution for 12 hours. Phytotoxicity symptoms, if any, on the fungicide treated plants was noted. Degree of disease development was also observed.

### c) Testing the residual toxicity of the fungicide on silkworm :

The residual toxicity of Bavistin which showed promising results was assessed by regularly feeding the leaves from fungicide treated plants to the silkworm larvae

(race NB4D2). Another set of larvae were fed with leaves from a healthy plant. Mortality, differences in their behaviour and changes, if any, in the commercial characters of the cocoon were observed.

## RESULTS AND DISCUSSION

### a) In vitro toxicity of fungicides :

Of the six fungicides studied, except Blitox and Karathane, all others inhibited the growth of the fungus at different concentrations (table 1 and figure 1). Comparatively, Captan was less effective as it inhibited the growth of the fungus only at the highest concentration tried (500 ppm). Dithane M-45 and Z-78 were better fungicides as they inhibited fungus growth at lower concentrations viz., 100 ppm and 150 ppm respectively. Significant inhibition of fungus growth was obtained with Bavistin. It did not allow the fungus to grow in any of the concentrations tried. Therefore, concentrations lower than 50 ppm i.e., 40, 30, 20 and 10 ppm were also tried. It was interesting to note that Bavistin was inhibitory to the growth of the fungus at even as low a concentration as 10 ppm.

### b) In vivo effect of the fungicide :

All the Bavistin pre- and post-treated stem cuttings sprouted well and their vegetative growth was also normal and healthy. Stem canker disease symptoms were never seen. Thus, the fungicide exhibited good preventive as well as curative action against the pathogen causing the stem canker disease. Sprouting and growth of fungus treated stem cuttings (control) was drastically affected compared to normal healthy plant (Figure II).

### c) Residual toxicity of the fungicide on silkworm :

As Bavistin is a systemic fungicide, its residual toxicity, if any, in the sprouted leaves was also assessed. The larvae fed with leaves from fungicide treated plants were as healthy as the larvae fed with leaves from healthy plants. There was no mortality and the commercial characters of the cocoon was also not disturbed.

## CONCLUSION

The systemic fungicide-Bavistin was neither toxic to the mulberry plant nor to the silkworm which is dependent on mulberry for its food. It is, therefore, possible from the present findings, to recommend a soaking pre-treatment for mulberry stem cuttings before planting, as a preventive measure, in 10 ppm solution of Bavistin for 12 hours to check stem canker disease caused by *B. theobromae*. It is essential to leave the soaked cuttings in shade for two to three hours before planting in the field. An additional advantage of using the systemic fungicide is that it can remain in the plant body and afford protection against infection for a longer period. It is also economical and safe to use Bavistin as it is effective at a concentration as low as 10 ppm.

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| Fungicides      | Average colony diameter (cm) |    |     |     |     |     |     |     |     |     |     |
|-----------------|------------------------------|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|                 | Concentration in ppm         |    |     |     |     |     |     |     |     |     |     |
|                 | Control                      | 50 | 100 | 150 | 200 | 250 | 300 | 350 | 400 | 450 | 500 |
| 1. Bavistin 50  | 9                            | -- | --  | --  | --  | --  | --  | --  | --  | --  | --  |
| 2. Blitox 50    | 9                            | 9  | 9   | 9   | 9   | 9   | 9   | 9   | 9   | 9   | 9   |
| 3. Captan       | 9                            | 9  | 9   | 9   | 9   | 9   | 9   | 9   | 9   | 4   | --  |
| 4. Dithane M-45 | 9                            | 9  | --  | --  | --  | --  | --  | --  | --  | --  | --  |
| 5. Dithane Z-78 | 9                            | 9  | 9   | --  | --  | --  | --  | --  | --  | --  | --  |
| 6. Karathane    | 9                            | 9  | 9   | 9   | 9   | 9   | 9   | 9   | 9   | 9   | 9   |

-- = No growth, indicates complete inhibition.

Table 1. Average colony diameter of Botryodiplodia theobromae Pat. at different concentrations of fungicides after seven days of incubation.

FIGURE I. : EFFECT OF DIFFERENT FUNGICIDES ON THE GROWTH OF  
BOIRYODIPLDIA THEOBROMAE PAT.

- 1 = Captan at 450 ppm concentration
- 2 = Karathane at 500 ppm concentration
- 3 = Blitox at 500 ppm concentration
- 4 = Bavistin at 10 ppm concentration
- 5 = Dithane M-45 at 100 ppm concentration
- 6 = Dithane Z-78 at 150 ppm concentration

FIGURE II. : EFFECT OF BAVISTIN ON MULBERRY PLANTS (M5 VARIETY)

- 1 = Normal healthy plant
- 2 = Plants from fungicide (Bavistin)  
treated stem cuttings
- 3 = Stem cuttings treated with the fungus  
Note inhibition of sprouting and  
retarded growth

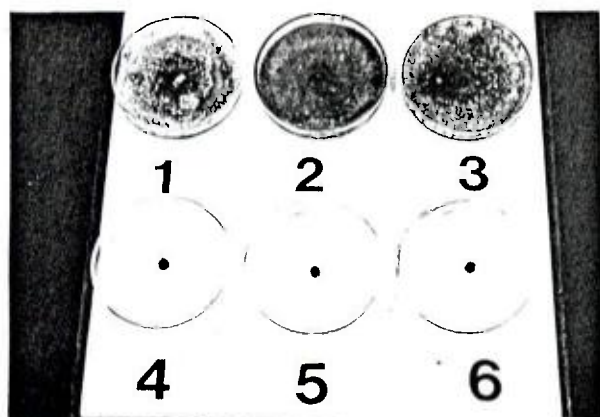


FIGURE-I

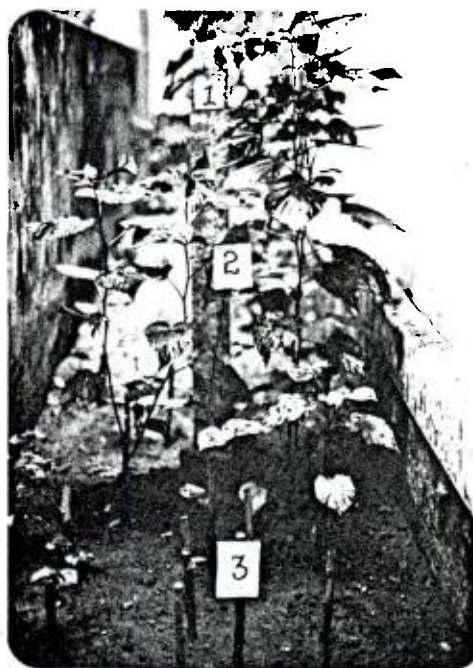


FIGURE II

## MULBERRY VARIETIES, EXPLOITATION AND PATHOLOGY

## VARIETES DE MURIER, EXPLOITATION ET PATHOLOGIE

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In recent years India has emerged as a major silk producing country in the tropical belt which has developed a new production technology, which with minor modifications can hold good for other countries in the tropical zone.

*Morus* is a typical east Asian genus distributed in temperate, sub-tropical and tropical regions of the world. *M. alba* Linn., *M. indica* Linn., *M. serrata* Linn. and *M. levigata* Wall. are the species of Indian origin. There are, however, many introductions from time to time from other countries. Indigenous as well as introduced genetic resources have been exploited for evolving improved strains by selection (*K<sub>2</sub>*, *S<sub>799</sub>* etc.) from open pollinated seedlings, controlled hybridization and selection (*EB* x *KOS*; *AB* x *Phil.*, *BC<sub>10</sub>*, *C<sub>776</sub>* etc.) and mutation breeding (*S<sub>30</sub>*, *S<sub>36</sub>*, *S<sub>41</sub>* and *S<sub>54</sub>*).

New strains were further subjected to better agronomical practices. Under irrigated conditions, in Kanva-2 variety, with a spacing of 60 x 23 cm, a manurial schedule of 300 kg of N: 120 kg P: 120 kg K. per hectare/year, irrigation over 10 to 15 days interval, pruning at a height of 6 to 8 cm, the leaf production was increased from 15 to 35 tonnes and 43 tonnes with *S<sub>54</sub>*.

The Central Sericultural Research and Training Institute (CSRI TI), Mysore has developed a new planting technology to increase the leaf production in the rainfed areas which covers nearly 53 percent of the total mulberry area in India. Here the three cuttings are planted at a spacing of 90 x 90 cm in pits of 45 x 45 x 45 cm at equivalent angles and a manurial schedule of 100:50:50 kg of N.P.K./ha/year is followed. This practice has increased the yield of local and Kanva-2 varieties from 4 tonnes to 12 tonnes and 15 tonnes respectively.

Evolving suitable varieties for draught resistance has been in progress at this Institute. Initially, two strains viz. RFS-135 and RFS-175 were isolated. In addition to these, 92 strains

are being screened for the desirable characters for dry farming system.

Mulberry is susceptible to the attack of various diseases like leaf-spot, powdery mildew, leaf rust and root-knot nematode and pests like thrips, jassids, tukra, black scale etc. Research Institutions in India have worked out of these problems and suggested preventive/control measures.

The author has also suggested future programme in mulberry research for improvement of sericulture in tropical countries.

Depuis quelques années l'Inde est apparue comme l'un des principaux pays producteur de soie de la ceinture tropicale et a développé une nouvelle technologie de production qui, avec de légères modifications, peut s'appliquer à d'autres pays de la zone tropicale.

*Morus* est un genre typique de l'Asie de l'Est que l'on trouve dans les régions tempérées, sub-tropicales et tropicales du monde. *M. alba* Linn., *M. indica* Linn., *M. serrata* Linn. and *M. levigata* Wall. sont des variétés d'origine indienne. De nombreuses variétés provenant d'autres pays sont cependant introduites de temps en temps. Les variétés indigènes ainsi que les autres variétés introduites ont été exploitées pour produire des variétés améliorées obtenues par sélection ( $K_0$ ,  $S_{299}$ , etc.) à partir de plants pollinisés naturellement, d'hybridation et de sélection contrôlée (EB x KOS; AB x Phil., BC<sub>10</sub>, C<sub>776</sub> etc.) et de mutation ( $S_{30}$ ,  $S_{36}$ ,  $S_{41}$  and  $S_{54}$ ).

Ces nouvelles variétés ont ensuite été soumises à de meilleures méthodes agronomiques, la variété Kanva-2, plantée en zone irriguée avec un espacement de 60 x 23 cm et une quantité d'engrais de 300 kg de N; 120 kg de P; 120 kg de K. par hectare et par an, irriguée tous les 10 à 15 jours, taillée à une hauteur de 6 à 8 cm, a vu sa production de feuilles passer de 15 à 35 tonnes; elle atteint 43 tonnes pour  $S_{54}$ .

Le CSRTI de Mysore a mis au point une nouvelle technique de plantation qui permet d'augmenter la production de feuille dans les régions pluvieuses qui représentent en Inde presque 53% des régions plantées de mûriers. Dans ces régions, les trois boutures sont plantées avec un espacement de 90 x 90 cm dans des trous carrés de 45 cm et côté et de 45 cm de profondeur et avec une quantité d'engrais de 100 kg de N, 50 kg de P et 50 kg de K par hectare et par an. Cela a permis à la race locale d'augmenter sa production de feuille qui est passée de 4 à 12 tonnes et a atteint 15 tonnes chez Kanva-2.

Des progrès ont été faits dans la mise au point de variétés résistantes à la sécheresse. Initialement, deux variétés, RFS-135 et RFS-175 avaient été isolées pour les zones sèches. En plus de celles-ci, 92 variétés sont sélectionnées pour leur adaptabilité à la sécheresse.

Le mûrier est sensible à diverses maladies comme la maladie de la tache de la feuille, le mildiou en poudre, la rouille de la feuille, le nématode de la racine et à des parasites comme les thrips, les jassids, le tukra, la teigne etc. Les Instituts de Recherches indiens ont étudié ces problèmes et proposé des mesures de prévention et de contrôle.

L'auteur propose également un programme de recherche sur le mûrier destiné à améliorer la sériciculture dans les pays tropicaux.

## INTRODUCTION

In recent years, India has emerged as a major silk producing country in the tropical belt. Indian sericologists have developed a new production technology which with appropriate modification can hold good for all the tropical countries of the world. The new technology is for both mulberry production and silkworm rearing (Jolly, 1981).

Active sericulture research in India dates back to 1960. Within a short span of nearly two and a half decades, remarkable achievements were made to maximise the mulberry leaf yield through evolution of high yielding mulberry strains which were further exploited through better agronomic practices. Concomitantly the development of new silkworm rearing technology not only enabled to double the cocoon crop yield, but also introduction of bivoltine silkworm breeds even in non-traditional areas, where climatic factor was considered to be a major constraint. The impact of the new technology over the traditional temperate technology followed till 1960 has been compared in Table 1.

Indian sericulture technology has been successfully introduced in many tropical countries such as Sri Lanka, Papua New Guinea, Mauritius, Bangladesh, Indonesia and Malaysia to increase silk production. The same technology can also be adopted in all other countries of the tropical zone where sericulture is practiced or newly introduced.

## MULBERRY VARIETIES

### 1. Distribution of Morus in tropical countries.

Mulberry is a fast growing deciduous tree occurring in sub-tropical, tropical and temperate climates of the northern hemisphere. It occurs indigenously in the north and west Asia, Thailand, Malaysia, Burma, Bangladesh, India, Pakistan, Turkey, North Iran, Armenia, Syria and Arabia. In Europe it is found in Italy, France, Austria, Hungary, Spain, Rumania, Greece and southern U.S.S.R. In America, it occurs in the south eastern part of Canada, eastern parts and coastal districts of United States, Mexico and in Central and South America (Fig. 1).

The genus *Morus* to which mulberries belong may be considered as a typical east Asian genus. As fodder plant for the silkworm, the diploid species *Morus alba* Linn. has been widely disseminated in all the countries of Asia from very early times. Only *Morus rubra* is indigenous to America which resembles Siberian form of *M. alba* (Janaki Ammal, 1960).

| Factors                        | Production level     |                  |                 | Improvement<br>over 1960<br>(%) |
|--------------------------------|----------------------|------------------|-----------------|---------------------------------|
|                                | Temperate<br>(Japan) | Tropical<br>1983 | (India)<br>1960 |                                 |
| 1. Mulberry leaf yield (kg/ha) |                      |                  |                 |                                 |
| Irrigated                      | 16,000               | 25,000           | 15,000          | 66.7                            |
| Rainfed                        | -                    | 10,000           | 4,000           | 250.0                           |
| 2. Cocoon yield (kg/ha)        |                      |                  |                 |                                 |
| Irrigated                      | 583                  | 1,000            | 400             | 150.0                           |
| Rainfed                        | -                    | 325              | 120             | 170.8                           |
| 3. Cocoon production (kg/box)  | 31.1                 | 17.5             | 10              | 75.0                            |
| 4. Renditta                    | 5.1                  | 10               | 15              | 50                              |
| 5. Raw silk production (kg/ha) |                      |                  |                 |                                 |
| Irrigated                      | 108                  | 100              | 30              | 233.3                           |
| Rainfed                        | -                    | 25               | 8               | 212.5                           |

Table 1. Impact of the new production technology

#### a) Indigenous species

The cultivation of mulberry in India goes to antiquity. There are four distinct varieties of mulberry in India which are sometimes referred as species, viz. *M. alba* Linn., *M. indica* Linn., *M. serrata* Linn. and *M. leviogata* Wall.

Apart from these species, there are a number of ecotypes belonging mostly to *M. indica*, some of which are listed below:

|             |                  |
|-------------|------------------|
| Assamabola  | Mysore local     |
| Jatinuni    | Berhampore local |
| Sujanpur-1  | Brentul          |
| Sujanpur-2  | Botatul          |
| Sujanpur-3  | Tsaritul         |
| Sujanpur-4  | Dastur           |
| Sujanpur-5  | Mowlai           |
| Kaliakutahi | Dhar local       |

#### b) Introduced species

Kadambi (1949) reported that many varieties of mulberry were introduced into India from Europe, China and probably from Japan or the Philippines. *Morus multicaulis* commonly known as Philippine variety was introduced in India from China or the Philippines in 1840. *M. alba* var. *moretti*, *M. nigra* var. *lacinata* were introduced from Europe. In Kashmir, systematic cultivation of mulberry commenced in the eighties of the last century.

In addition to the species mentioned above, many other cultivated forms of mulberry were introduced from time to time from other countries. Some of the eco forms are listed below:

|                   |           |
|-------------------|-----------|
| Kosen             | Sanish-5  |
| Goshoerami        | Cattaeneo |
| Karyonezumigeishi | Rustelli  |
| Tsukasagawa       | Kokuso    |

#### c) Varieties of West Java

There are eight species distributed towards the western part of Java, which are the variants exhibiting certain peculiarities (Katsumata, 1972).

|                                      |                                        |
|--------------------------------------|----------------------------------------|
| <i>Morus nigra</i>                   | <i>M. alba</i> var. <i>macrophylla</i> |
| <i>M. alba</i>                       | <i>M. australia</i>                    |
| <i>M. multicaulis</i>                | <i>M. cathyana</i>                     |
| <i>M. alba</i> var. <i>tartanica</i> | <i>M. microvra</i>                     |

#### d) Varieties of the Republic of South Vietnam

|               |                         |
|---------------|-------------------------|
| Daw baw Trag. | ( <i>M. alba</i> )      |
| Daw baw Den   | ( <i>M. nigra</i> )     |
| Daw dwoi      | ( <i>M. nigra</i> )     |
| Daw cay       | ( <i>M. laevigata</i> ) |

The important feature of all these species is that they are ever green also different from those of Japan and West Java (Katsumata, 1973).

## 2. Taxonomy of Mulberry

There is a considerable amount of confusion as to the existing species and varieties of mulberry in India and this is not lessened by the confusion in the

nomenclature of species of *Morus* in the world. According to Kadambi (1949) the most important types of mulberry grown in India for rearing silkworms are *Morus alba* var. *multicaulis* as a bush crop and *M. alba* var. *atropurpurea* as a tree. Yegna Narayana Iyer (1954) recorded mulberry varieties some times referred as species *M. alba*, *M. indica*, *M. nigra*, *M. chinensis* and *M. multicaulis*. Gururajan (1960) suggested grouping of all the cultivated forms of mulberry in India into three species viz. *Morus alba*, *M. bombycis* and *M. latifolia*. Though many systems of classification were proposed, viz. Hotta on the basis of idioblasts, and Hirano based on peroxidase isozyme technique, none of them is satisfactory. Even in Japan, all the varieties available were classified under *M. alba*, *M. bombycis* and *M. latifolia*, but according to Hirano (1982), no apparent differences in leaf protein profiles were found, thereby suggested all the three under a single group.

### 3. Utilization of indigenous and introduced mulberry species as breeding material

#### a) Conservation of genetic resources

A total of 223 mulberry cultivars is being maintained at the Mulberry Breeding and Genetics Section of the CSRTI, Mysore, India. There are 78 indigenous strains, 44 exotic strains and 21 unknown accessions and 101 elite hybrids. It is also proposed to conserve these genetic resources at different locations. The material is being evaluated for desirable characters and used as a breeding material (Fig. 2).

#### b) Exploitation of natural heterogeneity

Mulberry is anemophilous and the species are highly cross compatible with each other, indicating that interspecific hybrids may be naturally produced by wind pollination. The natural interspecific hybridization and intraspecific hybridization and occurrence of spontaneous mutations are considered responsible for greater genetic variability among mulberry. The natural heterogeneity of open pollinated hybrid population was taken advantage of in selecting superior types of mulberry. Kanva-2 is such a selection which is the best material found to be superior than Local (Fig. 4). This strain is already popular with sericulturists. Similarly, S799, S1301 are the selections made at Central Sericultural Research and Training Institute, Berhampore.

Presently at CSRTI, Mysore has isolated 42 strains from a population of 6788 plants in 4 series.

#### c) Controlled hybridization and selection

High yielding strains of mulberry from interspecific and intervarietal crosses have been obtained at the Research Institutes located at Mysore and Berhampore. *M. indica* var. *assamabola* × *M. alba* var. *philippine*; *M. alba* var. *English black* × *M. latifolia* var. *kosen* are the best selected hybrids progenies from CSRTI, Mysore, India (Sastry et al., 1976). Das and Krishnaswami (1965) selected some promising strains from the hybrid progenies of *M. indica* × *M. latifolia* var. *kosen*; *M. alba* var. *dudhiawhite* × *M. latifolia* var. *kosen*, etc. from CSRTI, Berhampore.

#### d) Polyploidy breeding

Triploid varieties of mulberry are attributed with many desirable traits such as better shoot growth. Triploids are generally produced by crossing diploids (2n) and artificially induced tetraploids (4n). Das et al. (1970) produced triploids in the same way. The new cultivars of Japan, viz. *Shinkenmochi* and *Aobanezumi* were produced adopting similar method. 26 triploids produced at CSRTI, Mysore are being screened for the desirable characters.

#### e) Mutation breeding

Induced mutations by exposing to acute gamma radiations were obtained by Hazama (1968), Fujita and Nakajima (1972) in Japan with Kairio-nezumigaeshi variety of mulberry. Beneficial mutant strains were obtained for the first time at GSRTI, Mysore when the seeds of a true breeding monocious Kollegal-8, a selection from Berhampore variety were treated with EMS (Sastry et al., 1974).

In M<sub>2</sub> generation, 4 strains viz. S30, S36, S41 and S54 were isolated and tested under field trial experiment for a period of 4 years. All these strains were found superior to Kanva-2 (Table 2).

| Variety          | Leaf yield in kg/ha |         |         |         | Mean of<br>4 years<br>(kg/ha) | Index |
|------------------|---------------------|---------|---------|---------|-------------------------------|-------|
|                  | 1979/80             | 1980/81 | 1981/82 | 1982/83 |                               |       |
| S30              | 46,569              | 35,202  | 48,436  | 41,407  | 42,904                        | 119   |
| S36              | 47,503              | 41,023  | 52,061  | 47,997  | 47,146                        | 131   |
| S41              | 46,459              | 35,092  | 46,734  | 46,514  | 43,700                        | 121   |
| S54              | 49,205              | 41,133  | 51,787  | 45,636  | 46,940                        | 130   |
| AB x Ph.         | 41,352              | 33,389  | 41,407  | 41,187  | 39,334                        | 109   |
| Eb x Kos.        | 41,352              | 35,256  | 44,757  | 37,783  | 39,787                        | 110   |
| OPH <sub>1</sub> | 46,899              | 37,288  | 48,052  | 41,956  | 43,549                        | 120   |
| Kanva-2          | 36,300              | 30,369  | 39,540  | 38,332  | 36,135                        | 100   |
| CD at 5%         |                     |         |         |         | 1,752                         |       |

Table 2. Final yield trial of selected strains.

A multilocal trial experiment is being conducted under different agro-climatic regions to test the degree of adaptability. These will be released to the sericulturists soon.

#### f) Breeding/selection for specific characters

Breeding for drought resistant characters is of paramount importance where the rainfall is very low. Two strains viz. RFS-135 and RFS-175 were isolated (Sastry and Balachandra, 1976) as suitable to rainfed region which are now under final yield trial (Fig. 6, c & d). Apart from these 92 strains are being screened on certain morphophysiological parameters (Fig. 7) such as stomatal frequency, stomatal size, leaf thickness, cuticle thickness, palisade spongy parenchyma ratio, moisture percentage, moisture retention capacity, vertical growth of root. Dry weight of the root, root-shoot ratio by weight and length which are associated with drought resistance/avoidance in mulberry (Jolly and Dandin, 1983).

## EXPLOITATION THROUGH AGRONOMIC PRACTICES

In India, though agronomical research in mulberry is recent in origin, substantial achievements were made to maximise the mulberry leaf production at an economic cost. The fruitful results of research were quickly transferred to the sericulturists through extension services in the form of package of practices for irrigated as well as rainfed mulberry (Krishnaswami, 1978).

### 1. Conventional practices

Mulberry is a hard, perennial plant with deep and extensive root system capable of absorbing even the subsoil moisture and thrive under limited soil moisture condition. Different methods of mulberry cultivation are followed in different sericulture states in India, depending upon the climatic and soil conditions, system of plantations under rainfed and irrigated and the rearing seasons. In temperate zone, comprising states like Jammu & Kashmir, Himachal Pradesh and Punjab, mulberry is grown as trees whereas it is grown as a field crop in the form of bushes in Karnataka, West Bengal, Andhra Pradesh, Tamilnadu under tropical belt. Strip system of plantation is followed in West Bengal, where strips are separated 60 cm apart. 2-3 rows are planted in each strip at a distance of 15 cm with a spacing of 15 cm from plant to plant. In Karnataka, there are two systems of raising mulberry bushes namely row system and pit system (Fig. 4 & 5).

Mulberry cultivation is done under two sets of conditions namely irrigated and rainfed.

#### a) Irrigated

VARIETY: variety is local, whose response to irrigation and fertilizer is low.

SPACING: the spacing is 45 cm in between rows and 10-15 cm in between the plants. Because of the closer spacing, plants do not develop into healthy bushes and naturally the yield as well as quality of leaf remains low.

MANURES AND FERTILIZERS: farmers apply the manure and fertilizers arbitrarily.

#### b) Rainfed

SHALLOW PLANTING: very short length of cuttings are planted horizontally at a very shallow depth at the intersection points of plough furrows resulting in poor establishment of mulberry with number of gaps in the field.

POOR FERTILITY STATUS OF THE LAND: mulberry being a perennial crop requires replenishment of fertility status. Generally fertilizers are not applied except the addition of very little farm yard manure and five tonnes/ha.

PRUNING SYSTEM: farmers resort to very hazardous pruning of the mulberry bushes below the ground level with a blunt implement. In doing so, they generally split the wood and peel off the bark containing dormant buds from which regeneration of shoot takes place. This operation also leads to lot of failed pits resulting into poor yield of mulberry leaf.

### 2. Package of practices for irrigated mulberry

Agronomical research endeavours at the CSRTI, Mysore from 1964 to 1978 resulted in a package of practices with a potential yield of 35 tonnes/ha.

VARIETY: the recommended variety is K2 which responds well to irrigation and fertilizer.

**SPACING:** spacing should be 60 x 23 cm. The wider spacings help the plant to grow luxuriously and higher leaf yield of good quality.

**MANURES AND FERTILIZERS:** farm yard manure is to be applied at the rate of 20 tonnes/ha/year, in addition to NPK fertilizer at 300:120:120 kg.

1st crop: 60 kg N + 60 kg P + 60 kg K as complex fertilizer.

2nd crop: 60 kg N as straight nitrogenous fertilizer.

3rd crop: 60 kg N + 60 kg P + 60 kg K as complex fertilizer.

4th crop: 60 kg N as straight nitrogenous fertilizer.

5th crop: 60 kg N as straight nitrogenous fertilizer.

**IRRIGATION:** mulberry gardens are to be irrigated at an interval of 10 days for red soils and 15 days for black soil following furrow and bed methods.

**PRUNING:** shoot harvest is frequent. Pruning has to be carried out with sharp pruning saw or sickle at a common height of 10 cm (Kasiviswanathan et al., 1977 and 1979).

Experiments carried out during 1978 to 1983 with improved strains of mulberry have shown the interaction, between variety x spacing x nitrogen levels x shoot harvest. S54 yielded the maximum quantity of leaf i.e. 43 tonnes/ha at an economic cost (Chaudhury et al., 1983) (Table 3).

### 3. Package of practices for rainfed mulberry and dry farming technology

Major area under mulberry cultivation in tropical belt depends upon the erratic and unpredictable monsoon. Nearly 53 per cent of the area in India is under rainfed mulberry. Under these low rainfall conditions, the yield of mulberry/unit area is very low. There is a wide gap between irrigated and rainfed sericulture. There is a recurring cycle of drought. Research efforts at CSRTI, Mysore have resulted in meeting the challenge of the situation and developed dry farming technology of mulberry cultivation (Kasiviswanathan et al., 1977).

The new technology of mulberry dry farming comprises the following:

- 1) Deep ploughing - 30-35 cm by means of tractor.
- 2) Planting of three cuttings of 20-23 cm length in pits of 45 x 45 x 45 cm with a spacing of 0.9 x 0.9 m.
- 3) Improved strains of mulberry to be used.
- 4) Application of organic manure at 10 tonnes/ha/year.
- 5) Application of fertilizer at 100 kg N + 50 kg P + 50 kg K where N is applied in two split doses during July-August and September-October.
- 6) Pruning once a year at 10 cm height with a sharp pruning saw or sickle.

### DISEASES OF MULBERRY

Protection from diseases and pests is an important aspect in mulberry cultivation. There are different diseases of mulberry, caused by fungi, bacteria, viruses, nematodes and also mineral deficiencies. Diseases cause considerable loss in both the quality and quantity of leaf. The incidence of diseases varies with season, varieties and cultivation practices. Fungal diseases are more common and severe than other diseases. Some of the common diseases are a) leaf spot, b) powdery mildew, c) leaf rust and d) root-knot nematode disease.

Table 3. Response of new mulberry cultivars to different agronomical practices; interaction of variety x spacing x harvest method x nitrogen level (leaf yield in kg/ha) (Mean of 5 years - 1978-83).

Treatments : 80 (Eighty)

| Varieties (5)   | Spacings (4)       | Harvesting methods (2)          | Nitrogen levels (2) |
|-----------------|--------------------|---------------------------------|---------------------|
| $V_0$ = Kanva-2 | $S_0$ = 45 x 15 cm | $h_0$ = Whole shoot harvest     | $n_0$ = 300 kg N/ha |
| $V_1$ = S-30    | $S_1$ = 60 x 30 cm | $h_1$ = Step-wise shoot harvest | $n_1$ = 600 kg N/ha |
| $V_2$ = S-36    | $S_2$ = 60 x 45 cm |                                 |                     |
| $V_3$ = S-41    | $S_3$ = 60 x 60 cm |                                 |                     |
| $V_4$ = S-54    |                    |                                 |                     |

| Treatments | $h_0$        |        | $h_1$  |        |
|------------|--------------|--------|--------|--------|
|            | $n_0$        | $n_1$  | $n_0$  | $n_1$  |
| $V_0$      | $S_0$ 36,403 | 42,130 | 36,631 | 43,158 |
|            | $S_1$ 36,313 | 43,640 | 34,190 | 43,946 |
|            | $S_2$ 34,911 | 41,635 | 37,371 | 41,401 |
|            | $S_3$ 32,657 | 41,988 | 36,362 | 45,194 |
| $V_1$      | $S_0$ 39,427 | 47,108 | 39,023 | 50,710 |
|            | $S_1$ 37,608 | 46,859 | 37,910 | 46,893 |
|            | $S_2$ 36,083 | 44,607 | 41,338 | 45,224 |
|            | $S_3$ 37,296 | 48,257 | 37,722 | 49,643 |
| $V_2$      | $S_0$ 37,456 | 41,492 | 37,022 | 44,949 |
|            | $S_1$ 39,847 | 45,250 | 37,845 | 42,509 |
|            | $S_2$ 35,406 | 47,973 | 38,619 | 42,866 |
|            | $S_3$ 38,156 | 48,326 | 40,952 | 47,463 |
| $V_3$      | $S_0$ 33,192 | 35,270 | 32,122 | 37,764 |
|            | $S_1$ 33,193 | 38,980 | 33,849 | 38,583 |
|            | $S_2$ 31,909 | 34,383 | 33,500 | 37,615 |
|            | $S_3$ 33,974 | 39,241 | 33,320 | 38,713 |
| $V_4$      | $S_0$ 37,364 | 41,429 | 36,108 | 43,183 |
|            | $S_1$ 36,826 | 44,757 | 39,021 | 44,373 |
|            | $S_2$ 38,335 | 46,159 | 41,201 | 47,319 |
|            | $S_3$ 43,257 | 43,859 | 39,919 | 45,670 |
| C.D. at 5% | 3,596        |        |        |        |

### 1. Leaf spot disease

Fungal leaf spot caused by *Cercospora moricola* Cooke was reported in mulberry (*Morus indica* L.) by Patel et al. in 1949 (Fig. 8a). It is more common in rainy season (June-November). Field studies showed leaf yield loss was 9-12% and it may go upto 20% in severe cases due to this disease (Sikdar and Krishnaswami, 1980). The affected leaves are poor in their nutritive values and are not suitable for feeding silkworms. The disease not only causes considerable loss in leaf yield, but also affects the growth and development of silkworm larvae and yield and quality of cocoons (Sikdar et al., 1979). Two sprays of Difolatan 0.2% or Bavistin and Benlate (0.05% and 0.1%) have been found to be effective in controlling leaf spot disease and the leaves could be fed 10 days after last spray (Sikdar and Rao, 1975; Siddaramiah et al., 1978; Sikdar et al., 1979).

### 2. Powdery mildew disease

Powdery mildew disease caused by *Phyllactinia moricola* is common during winter (November-February) (Fig. 8b). The higher relative humidity and low temperature are favourable for the development of the disease (Krishnaprasad and Siddaramiah, 1979). The feeding of silkworms with diseased leaves affects the growth and development of larvae and cocoon characters (Suryanarayana and Ganesh, 1969; Noamani et al., 1970). Preliminary experiments showed that 0.2% Karathane and Morestan (0.1%) were effective against powdery mildew disease and the leaves could be fed after 10 days to silkworm (Sikdar and Rao, 1975; Iyengar, 1975; Siddaramiah et al., 1978).

### 3. Leaf rust disease

Mulberry rust disease caused by *Cerotelium fici* is common in late winter and early summer. The disease is noticed usually on older leaves (Fig. 8c). The leaf yield loss may be 5-10%. Most of the varieties of mulberry are susceptible to this disease in various degrees. Not much field work has been done on the control of the disease.

### 4. Root-knot disease

Root-knot disease in mulberry caused by *Meloidogyne incognita* (Kofoid and White) chitwood is common in sandy loamy soils (Narayanan et al., 1966). It has got wide host range and the parasite is soil borne, hence it is very difficult to eradicate the disease.

The nematode affects the root system and forms the characteristic knot/gall (Fig. 8d). Growth of the plant becomes very much stunted and reduce the leaf yield in severe cases. D.D. Mixture, Aldicarb at 3 kg ai/ha/year and Neem oil cake at 1 ton/ha/year, in 4 equal split dosage have been found to be effective in reducing the disease infestation and improvement of leaf yield (Sikdar and Sheno, 1980; Sikdar et al., 1983). The usage of Aldicarb and Neem oil cake is found to be economical.

In addition to the common diseases some minor diseases were also reported in mulberry, like bacterial leaf blight caused by *Pseudomonas mori* (Sinha and Saxena, 1966), stem canker caused by *Botryodiplodia theobroma* (Padmabailuke and Sathyapaul, 1981), root-rot disease caused by *Helicobasidium mompa* and *Rosellinia necatrix*.

Rayachaudhari and Chatterjee (1961-65) made some studies on viral and vector diseases like yellow net vein disease, and mosaic diseases.

Apart from the diseases caused by pathogenic agents, mulberry shows symptoms of deficiency of mineral elements. Nitrogen deficiency shows decline in growth and

leaves become chlorotic. In potassium deficiency, the stem and roots become thin and leaves show marginal necrosis. Phosphorous deficiency shows intraveinal chlorosis of leaves followed by marginal necrosis and defoliation. To overcome the mineral deficiencies, NPK fertilizers should be applied as per recommended dosages.

## PESTS OF MULBERRY

Due to regular cultural operations and repeated leaf harvest, incidence of pest menace in mulberry is comparatively limited. However, under the tropical condition, certain pests still find enough time and place in the plantations for increased breeding activity and to cause damage to the mulberry crop. Due to the pest menace, the quality of the leaf becomes unfit for rearing and also considerably reduces the yield per unit area.

### 1. Thrips

Thrips are commonly known as 'plant lice'. Among the five species so far reported from mulberry, *Pseudodendrothrips mori* (Nawa) causes major damage to the mulberry crop. Damage to the crop is affected due to ducking and scraping of the epidermal layer and thus reduces the quality of leaf. Affected leaves become leathery, less in moisture and thus rendered unfit for feeding. Due to the specific habit of thrips, the affected leaves give a scorching appearance (Fig. 9a).

Several overlapping generations are seen in one year. Adult thrips lay 30-50 eggs and deposit under the epidermis of the lower side of the leaf. After hatching, the thrips pass through two nymphal stages, one pre-pupal and one pupal stage.

CONTROL: spraying of 0.02% DDVP twice at weekly intervals is found to be effective in reducing the pest menace. Safe period for utilization of leaf is after 3 days of spraying (Kariappa and Narasimhan, 1978).

### 2. Jassids: *Empoasca flavescens* (Fb.)

Commonly known as 'leaf hoppers' are causing severe damage to leaf crop through the characteristic damage of leaf viz. 'hopper burn'. The insect is a small green coloured one, with wedge shaped body, with two brown spots on the distal end of the wing. Though jassids are seen throughout the year, severe damage to leaf crop is reported only during December to May period. It is known that the jassids introduce the toxic b virus through their feeding and causing the scorching or burning of leaf areas. Jassids lay eggs on the lower surface of the leaf and the incubation period is 4-9 days. The young stages are nymph, pre-pupa and pupa and the whole period lasts about 14-21 days depending upon the season.

CONTROL: spraying of 0.1% Rogor or 0.05% DDVP is effective. Safe period of leaf picking is 3 days after DDVP and 10 days after Rogor spraying (Kariappa and Narasimhan, 1978).

### 3. Tukra: *Maconellicoccus hirsutus* (G)

Commonly known as 'mealy bugs', causes the characteristic damage to the plant known as 'Tukra' (Fig. 9b). Affected plants show retarded growth in apical portions with distorted stem and leaf, and as such the growth and leaf yield are affected very much. The mealy bugs feed on the sap through sucking. It is not known whether through the above feeding the insects are introducing any virus and in causing the Tukra symptoms. The mealy bugs lay 150 eggs at a time and they hatch within 7 days. The

nymphs are covered with a waxy coat of powdery substance. They moult 5 times. Reproduction is through parthenogenesis.

CONTROL: cutting and burning the affected plants reduces the chances of disease. Spraying with 0.01% Malathion is found very effective. Safe period for use of leaf is after 10 days of spraying. Application of phoratax at 4 kg/ha reduces the disease to a great extent (Biswas and Sinha Deo, 1980).

#### 4. Black scale: *Saissetia nigra* (Fb.)

Locally known as 'black scale of mulberry', interferes with the growth of the plant and leaf production. The nymphs and adults suck the plant sap and as a result of the feeding, a sooty mould appears over the affected stems and the stems gradually decay and die.

Adult scales lay 300 to 600 eggs and keep under their scale until hatching. Eggs hatch within 6 days and very soon the young nymphs crawl out for feeding. Female nymphs moult thrice and the males twice during the developmental stages. Adults are sedentary and give a studded appearance over the plant (Fig. 9c). Reproduction is through parthenogenesis.

CONTROL: scrapping the affected plants with diesel oil emulsion is found to be very useful. Lime swapping also reduces the scale attack. Application of 0.05% Malathion or Nuvacron is recommended and the safe period is after 15 days of spraying.

#### 5. Black hairy caterpillar: *Diacrisia obliqua* (Walker)

Known as 'Bihar hairy caterpillar', damages the mulberry to a considerable extent. Due to the specific feeding of the caterpillars by swallowing the chlorophyll of the leaf, the affected leaves will be left out with only the veins. Since the pest is a gregarious one, especially in early stages, leaf destruction will be very quick, and later they migrate to neighbouring areas. Adult moth lays about 1000-1200 eggs in mass under the leaf and the eggs hatch within 5-7 days. The larvae pass through six moults. Mature larvae are with black markings on the anterior and posterior portions and with reddish brown in the rest of the body. Pupation takes place under the soil around the affected area.

CONTROL: use of light traps are advisable to trap the moths. Deep ploughing enables to expose the pupae and to destroy them. Spraying of 0.02% DDVP or Rogor is recommended for reducing the pest menace.

### PROJECTIONS/SUGGESTIONS FOR IMPROVEMENT OF MULBERRY IN TROPICAL COUNTRIES

1. Realizing the urgent need to have an effective research and development support for the sericultural industry of the tropical zone, an Institute similar to that of ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) should be established in tropical zone.

2. The Institute so established should serve as a Centre to improve genetic potential of mulberry and silkworm.

3. The Institute should conserve genetic resources of mulberry as indispensable genetic resources at various locations in the tropical belt.

4. The mulberry research should develop farming systems which will help to increase and stabilize cocoon production in irrigated and rainfed tracts.

5. The Institute should assist national and regional programmes through cooperation and support and contribute further by sponsoring conferences, operate training programmes on an international basis and assist extension activities.

6. The main Institutes should have close working linkage with national and regional institutions and agencies throughout the tropical area it could serve.

7. Rapid progress requires sharp focus. Hence the programmes should be confined to:

- a) collection and evaluation of germplasm for the tropics;
- b) planned utilization by mulberry breeders;
- c) its full exploitation by better agronomic practices;
- d) protection from diseases and pests.

8. Since tangeable achievements were made by Indian sericologists, it would be ideal if the main Institute is located in India, preferably at Mysore, as the International Centre for Training and Research in Tropical Sericulture is already located.

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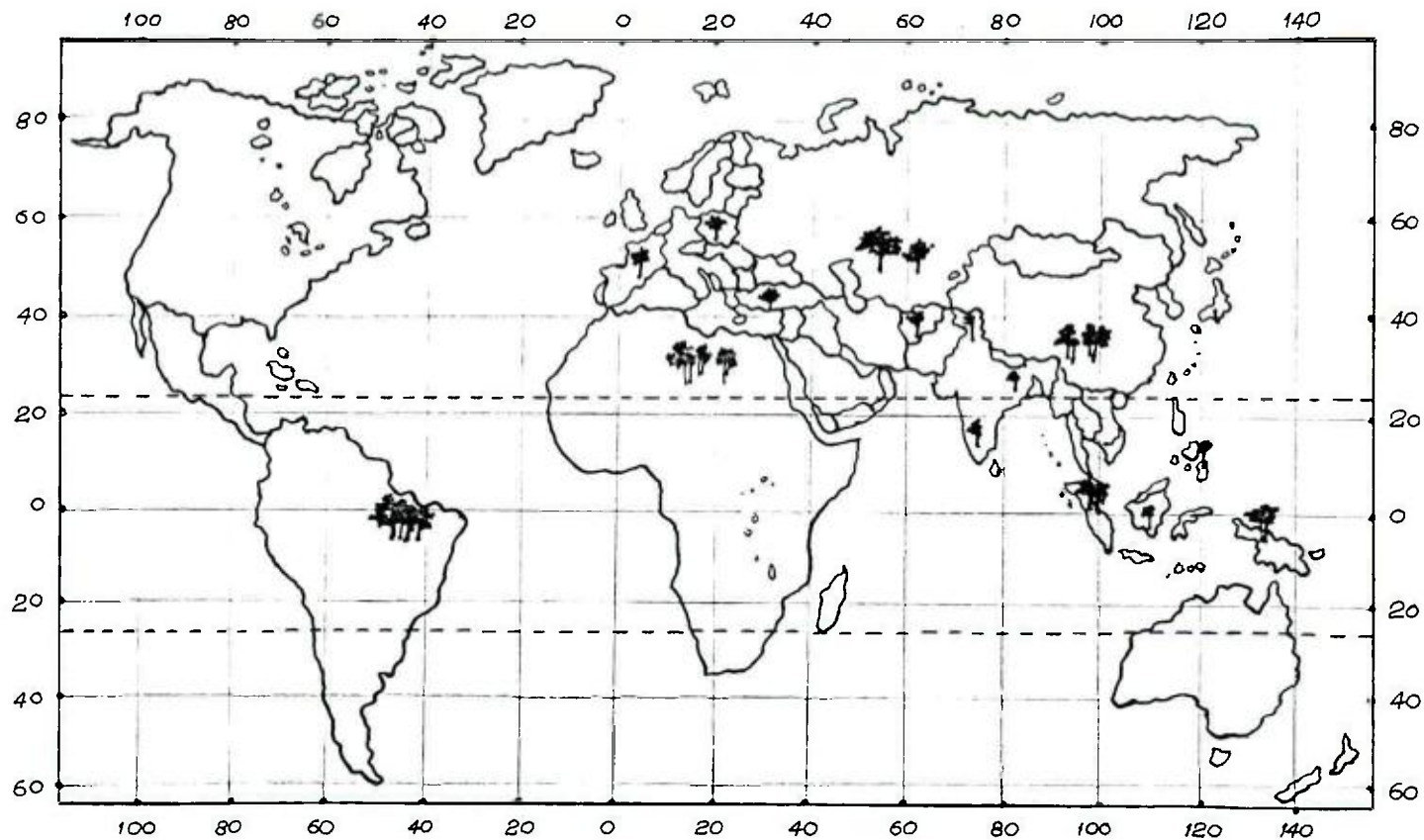
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Figure 1. GLOBAL DISTRIBUTION OF THE GENUS MORUS





*RUSTELLY*



*BLACK MULBERRY*



*GOSHOERAMI*



*ASSAMABOLA*

Figure 2. DIFFERENT MORPHOTYPES IN GERMPLASM VARIETIES OF MULBERRY



a. S\_30



b. S\_36



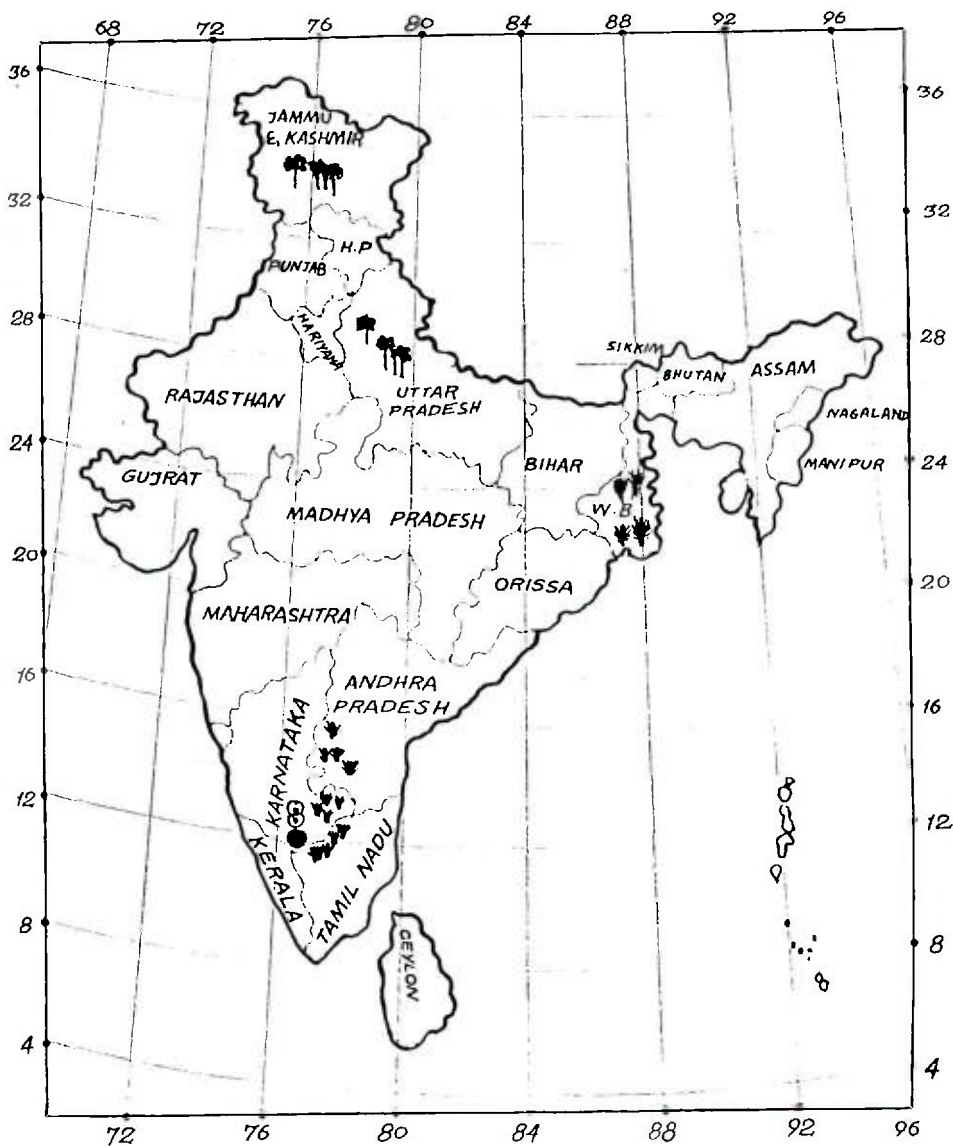
c. S\_41



d. S\_54

Figure 3. NEWLY EVOLVED MULBERRY STRAINS

Fig. 4. MULBERRY CULTIVATION IN INDIA



Reference :



Tree

Bush row system



Bush pit system irrigated

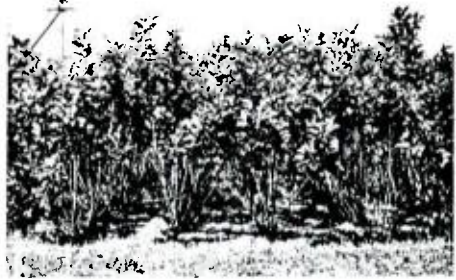


Bush pit system rainfed





*a. ROW SYSTEM*



*b. PIT SYSTEM*



*c. ROW SYSTEM PRUNED*

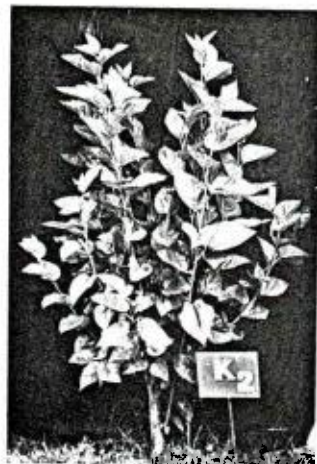


*d. PIT SYSTEM PRUNED*

Figure 5. SYSTEMS OF MULBERRY CULTIVATION



2. LOCAL



b. KANVA-2



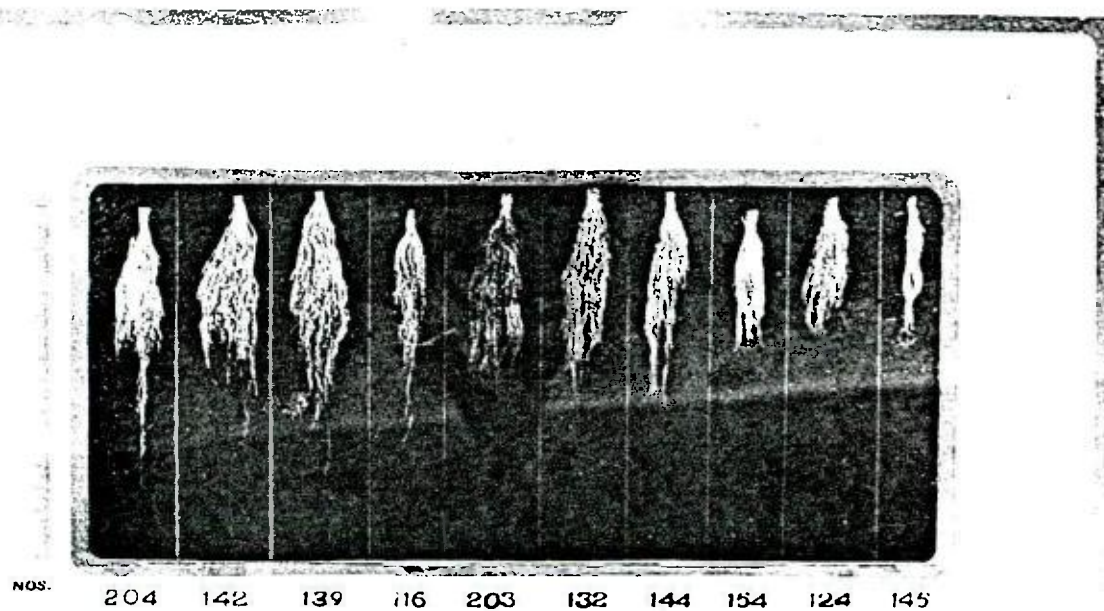
c. RFS-135



d. RFS-175

Figure 6. VARIETIES OF MULBERRY

Figure 7. ROOT PROLIFERATION STUDIES FOR RAINFED MULBERRY





*a. LEAF SPOT*



*b. MILDEW*



*c. RUST*



*d. ROOT KNOT*

Figure 8. DISEASES OF MULBERRY

Figure 9. PESTS OF MULBERRY



**B. THRIPS AFFECTED LEAF**



**b. TUKRA**



**C. STEMS AFFECTED WITH  
BLACK SCALES**



**d. LEAVES AFFECTED  
WITH BIHAR HAIRY  
CATERpillARS**



*f. JASSIDS AFFECTED PLANTS*

STUDIES ON THE COMPARATIVE PERFORMANCE OF SILKWORM RACES  
AGAINST DIFFERENT VARIETIES OF MULBERRY UNDER  
MARATHWADA CONDITIONS

ETUDES COMPARATIVES DES PERFORMANCES DES RACES DE VERS A SOIE  
ELEVEES DANS LES CONDITIONS DE MARATHWADA AVEC DIFFERENTES  
VARIETES DE MURIER

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Comparative merits of four varieties of mulberry viz. Kanva-2, S-54, Kosen and LM-2 on the cocoon qualities of two bivoltine races (NB<sub>7</sub> and NB<sub>18</sub>) and a hybrid race (PM x NB<sub>18</sub>) were tested. The S-54 showed higher values in different characters namely in larval duration, larval weight, single cocoon weight and cocoon yield. The hybrid PM x NB<sub>18</sub> proved superior in cocoon yield.

Nous avons testé et comparé la qualité des cocons de deux races bivoltines (NB<sub>7</sub> and NB<sub>18</sub>) et d'une race hybride (PM x NB<sub>18</sub>) obtenus avec quatre variétés de mûrier : Kanva-2, S-54, Kosen et LM-2. La variété S-54 donne de meilleurs résultats pour ce qui concerne la durée de la période larvaire, le poids de la larve, le poids et le rendement des cocons. L'hybride PM x NB<sub>18</sub> est le meilleur du point de vue du rendement des cocons.

INTRODUCTION

The importance of quality of mulberry leaves on the growth, development, health and silk production in *Bombyx mori* was stressed by Yokayama (1963). The development of silk industry largely depend upon the use of improved breeds of silkworm, the production of quality leaves through better mulberry varieties and method of rearing. The effect of varietal feeding on silkworm was reported by Das and Sikdar (1970), Krishnaswami *et al.* (1971), Kushwaha and Verma (1978), Radha *et al.* (1978) and Venugopala *et al.* (1980). The present studies were therefore carried out to assess the varietal effect of different mulberry varieties on three silkworm breeds under Marathwada condition.

## MATERIALS AND METHODS

The improved varieties of mulberry selected for the experiment were Kanva-2, S-54, Kosen with the local variety LM-2 as a control. Three silkworm races used for the feeding experiment were NB<sub>7</sub>, NB<sub>18</sub> and PM x NB<sub>18</sub>. The Experiment was conducted during December 1980-January 1981 with three replications under each treatment. The experiment was laid out in F.R.B.D. design comprising twelve treatment combinations. After second moult, 100 larvae in each treatment were maintained. The improved technique of silkworm rearing described by Krishnaswamy (1978) was used during the rearing of silkworm. The data recorded in respect of larval duration, weight of 10 mature larvae, single cocoon weight and shell content.

## RESULTS AND DISCUSSIONS

### a) Effect of varieties :

The data presented in Table 1 indicate that the variety S-54 reduced the larval duration significantly and also showed significant higher weight of larvae and weight of single cocoon over other varieties under test. The shell percentage was significantly lower in the case of Kanva-2 than Kosen, S-54 and LM-2. The cocoon yield observed was significantly higher in the case of S-54 followed by Kosen. Venugopala *et al* (1980) observed that the variety S-54 was the next best to MR-2 variety in the order of efficiency when they tested five cultivars viz. MR-2, Roso, Kanva-2 and Kosen.

### b) Effect of silkworm races :

The hybrid PM x NB<sub>18</sub> matured earlier than NB<sub>7</sub> and NB<sub>18</sub>. The PM x NB<sub>18</sub> also showed higher larval weight, single cocoon weight and cocoon yield over NB<sub>7</sub> and NB<sub>18</sub>. The shell percentage was higher in the case of NB<sub>18</sub> than NB<sub>7</sub> and PM x NB<sub>18</sub>.

### c) Effect of varieties of mulberry x races of silkworm :

The larvae of PM x NB<sub>18</sub> when fed on S-54 showed shorter larval duration. Similarly it weighted significantly higher when reared on Kanva-2 and S-54. The higher single cocoon weight was observed when the larvae of NB<sub>7</sub> reared on S-54. The larvae of NB<sub>18</sub> reared on Kosen proved better in shell percentage. The cocoon yield recorded significantly higher when the larvae of PM x NB<sub>18</sub> fed with the leaves of S-54 and Kanva-2.

The variety S-54 was the best in the order of efficiency and silkworm hybrid race PM x NB<sub>18</sub> proved superior in yield quality.

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\* \* \*

(see table 1. on the versus)

Table 1. Varieties of mulberry versus performance of silkworm races season.

| Sr. No | Treatment                                   | Larval duration (av. days) | Weight of 10 mature larvae (gm) | Weight of single cocoon (gm) | * Shell percentage | Yield/10,000 larvae brushed (kg) |
|--------|---------------------------------------------|----------------------------|---------------------------------|------------------------------|--------------------|----------------------------------|
| 1.     | Varieties of mulberry :                     |                            |                                 |                              |                    |                                  |
| 1.1    | Kanva-2                                     | 29.67                      | 38.944                          | 1.241                        | 29.11              | 10.065                           |
| 1.2    | Kosen                                       | 29.11                      | 36.253                          | 1.399                        | 30.47              | 11.431                           |
| 1.3    | S-54                                        | 28.06                      | 40.567                          | 1.555                        | 30.02              | 14.268                           |
| 1.4    | LM-2                                        | 29.61                      | 37.768                          | 1.398                        | 30.45              | 11.236                           |
|        | S.E. $\pm$                                  | 0.547                      | 0.572                           | 0.020                        | 0.350              | 0.717                            |
|        | C.D. (p = 0.05)                             | 1.604                      | 1.677                           | 0.061                        | 1.027              | 2.104                            |
| 2.     | Races of silkworm :                         |                            |                                 |                              |                    |                                  |
| 2.1    | Pure Mysore x NB-18                         | 27.79                      | 39.953                          | 1.484                        | 29.62              | 14.432                           |
| 2.2    | NB-7                                        | 29.46                      | 38.068                          | 1.431                        | 29.60              | 11.627                           |
| 2.3    | NB-18                                       | 30.08                      | 37.229                          | 1.280                        | 30.83              | 9.193                            |
|        | S.E. $\pm$                                  | 0.469                      | 0.495                           | 0.018                        | 0.303              | 0.621                            |
|        | C.O. (P = 0.05)                             | 1.375                      | 1.453                           | 0.052                        | 0.889              | 1.822                            |
| 3.     | Varieties of mulberry x races of silkworm : |                            |                                 |                              |                    |                                  |
| 3.1    | Kanva-2 x (PM x NB-18)                      | 27.83                      | 41.00                           | 1.511                        | 29.57              | 15.116                           |
| 3.2    | Kanva-2 x NB-7                              | 29.83                      | 38.195                          | 1.423                        | 30.74              | 9.020                            |
| 3.3    | Kanva-2 x NB-18                             | 31.33                      | 36.938                          | 0.790                        | 27.03              | 8.060                            |
| 3.4    | Kosen x (PM x NB-18)                        | 28.17                      | 37.498                          | 1.495                        | 30.63              | 13.700                           |
| 3.5    | Kosen x NB-7                                | 29.00                      | 35.293                          | 1.373                        | 28.43              | 11.956                           |
| 3.6    | Kosen x NB-18                               | 30.17                      | 35.970                          | 1.330                        | 32.36              | 8.645                            |
| 3.7    | S-54 x (PM x NB-18)                         | 27.17                      | 41.570                          | 1.540                        | 29.04              | 15.416                           |
| 3.8    | S-54 x NB-7                                 | 28.50                      | 40.353                          | 1.600                        | 29.17              | 14.668                           |
| 3.9    | S-54 x NB-18                                | 28.50                      | 39.443                          | 1.525                        | 31.86              | 12.721                           |
| 3.10   | LM-2 x (PM x NB-18)                         | 28.00                      | 38.308                          | 1.390                        | 29.24              | 13.497                           |
| 3.11   | LM-2 x NB-7                                 | 30.50                      | 38.431                          | 1.330                        | 30.05              | 10.865                           |
| 3.12   | LM-2 x NB-18                                | 30.33                      | 36.566                          | 1.476                        | 32.07              | 9.346                            |
|        | S.E. $\pm$                                  | 0.264                      | 0.286                           | 0.010                        | 0.175              | 0.358                            |
|        | C.D. (P = 0.05)                             | 0.775                      | 0.839                           | 0.030                        | 0.513              | 1.052                            |

\* Transformed values.

PRELIMINARY STUDIES ON THE TAXONOMY OF INDIAN  
MULBERRY VARIETIES

ETUDES PRELIMINAIRES SUR LA TAXONOMIE DES VARIETES  
INDIENNES DE MURIER

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*The taxonomy of mulberry (Morus) has created enough confusion since different taxonomists have used different yardsticks for the classification of species and varieties. In order to evaluate and describe all the varieties both, indigenous and exotic, growing in India, as a first step, a germplasm bank of most of the populations has been established at the Bangalore University Campus, India. Morphological and growth data have been collected for every 30 days for 150 days and the average has been given while describing varieties. A systematic study using all the morphological characters has enabled us to give a brief description for 15 indigenous and 5 exotic varieties that are being cultivated in India. Further, it is also felt that an intensive survey of cultivars/varieties has to be carried out, a germplasm bank has to be established and later, a biosystematic approach has to be made to solve the confusion in mulberry taxonomy.*

*La taxonomie du mûrier (Morus) est confuse car les taxonomistes utilisent différentes méthodes de classification des espèces et des variétés. Afin d'évaluer et de décrire toutes les variétés à la fois indigènes et exotiques poussant en Inde, une banque des graines de la plupart des espèces a été créée dans un premier temps sur le campus de l'Université de Bangalore, Inde. Des données morphologiques et sur la croissance ont été enregistrées tous les 30 jours pendant 150 jours et la moyenne a été utilisée pour décrire les variétés. Une étude systématique utilisant tous les caractères morphologiques nous a permis de donner une brève description de 15 variétés indigènes et de 5*

*variétés exotiques cultivées en Inde. De plus nous pensons qu'une étude intensive sur les variétés/cultivars doit être faite, qu'une banque de graines doit être créée et que, par la suite, une approche biosystématique doit être faite pour dissiper la confusion qui existe dans la taxonomie du mûrier.*

## AIR-SPORA OF MULBERRY FARMS IN BANGALORE

### SPORES DANS L'ATMOSPHERE DES PLANTATIONS DE MURIERS A BANGALORE

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Air-spores of two mulberry farms were recorded by trapping the fungal spores to investigate relationships in order to assess the interaction of pathogen and environment in disease production. The two mulberry farms selected were maintained by the Bangalore University under the Research Development Programme in Sericulture. One farm was located at the Central College Campus and the other at the Jnana Bharathi Campus of Bangalore University, the distance between two being about 12 km.

Air-spores of the two farms were recorded by trapping the fungal spores on an improvised portable battery operated rotorod. The spore catches were obtained by periodical air sampling using adhesive coated cellophane tape. This method allowed sampling of air-borne fungal spores of obligate, facultative and saprophytic forms. The fungal flora of the atmosphere was also studied by exposing culture plates in the areas of mulberry farms. Recorded data indicated the relationship between air borne fungal spores and the fungal diseases of mulberry. The air spora reports are based on data obtained in twelve months from January 1983 to December 1983. The air-borne spores were identified based on their key characteristics. The fungal spores observed in air samples belonged to the following genera :

Acremonium, Aspergillus, Alternaria, Aecidium, Bispora, Blakeslea, Botryodiplodia, Cephalosporium, Cercospora, Chaetomium, Cladosporium, collectotrichum, Curvularia, Chlamydomyces, Drechslera, Epicoccum, Fusariella, Fusarium, Helminthosporium, Melanospora, Memmoniella, Monocillium, Monosporium, Mucor, Myrothecium, Nigrospora, Paecilomyces, Penicillium, Phyllactinia, Pyricularia,

Sclerotium, Torula, Trichothecium and Ustilago. Of the genera trapped, the following were known mulberry pathogens :

Aecidium mori, Phyllactinia corylea (obligate parasites), Cercospora moricola (facultative parasites) and Alternaria alternata (opportunists). Observed records showed that no season is free of fungal spores in the air. Among fungal spores observed two were Phycomycetes, five Ascomycetes, two were Basidiomycetes and twenty five were Detruromycetes. An Ascomycete Phyllactinia corylea (pers.) Karst, showed maximum incidence of air-spores during December, January and February. The seasonal variations and effects of different meteorological conditions were observed in spore concentration. They were found related to the inoculum and the time of spore liberation at the prevailing weather conditions.

Les spores aériennes de deux plantations de mûrier ont été relevées en trappant les spores fongiques afin de déterminer l'interaction du pathogène et de l'environnement dans la maladie. Les deux plantations sélectionnées sont entretenues par l'Université de Bangalore dans le cadre du programme de la Recherche et de développement de la Sériciculture. L'une des plantations est située sur le campus de la Faculté Centrale, l'autre se trouve sur le campus de Jnana Bharathi de l'Université de Bangalore. Ces deux plantations sont distantes de 12 km.

La capture des spores a été faite en prélevant périodiquement des échantillons d'air au moyen d'une bande de cellophane adhésive pour étudier les spores fongiques de type obligatoire, facultatif ou saprophyte portées par l'air. La flore fongique de l'atmosphère a également été étudiée au moyen de lamelles de culture exposées à l'air à proximité des plantations. Les informations obtenues montrent une relation entre les spores fongiques portées par l'air et les maladies fongiques des mûriers. Les informations sur les spores de l'air ont été obtenues sur 12 mois, de janvier à décembre 1983. Les spores de l'air ont été identifiées par leurs caractéristiques-clés. Les spores fongiques observées dans les échantillons d'air appartiennent aux espèces suivantes :

Acromonium, Aspergillus, Alternaria, Aecidium, Bispora, Blakeslea, Botryodiplodia, Cephalosporium, Cercospora, Chaetomium, Cladosporium collectotrichum, Curvularia, Chlamydomyces, Drechslera, Epicoccum, Fusariella, Fusarium, Helminthosporium, Melanospora, Memmoniella, Monocillium, Monosporium, Mucor, Myrothecium, Nigrospora, Paecilomyces, Penicillium, Phyllactinia, Pyricularia, Sclerotium, Torula, Trichothecium and Ustilago. Parmi les espèces trappées, certaines sont connues comme pathogènes du mûrier : Aecidium mori, Phyllactinia corylea (parasites permanents), Cercospora moricola (parasites facultatifs) et Alternaria alternata (opportunistes). L'air est porteur de spores fongiques à toutes les saisons. Parmi les spores fongiques observées, il y a 2 hycomycetes, 5 Ascomycetes, 2 Basidiomycetes et 25 Detruromyces. Un ascomycete, Phyllactinia corylea (pers.) Karst. a une incidence maximale en décembre, janvier et février. Les variations saisonnières et les effets des conditions météorologiques sont observées dans les concentrations de spores. Elles sont liées à l'inoculum et au temps de libération de la spore dans les conditions atmosphériques prédominantes.

## MULBERRY VARIETIES, EXPLOITATION AND PATHOLOGY

## VARIETES DE MURIER, EXPLOITATION ET PATHOLOGIE

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*The classification and distribution of mulberry in Japan and India have been stated. The evolution of improved strains of mulberry for commercial exploitation by conventional, polyploid and backcross methods of breeding has been described. The commonly occurring diseases of mulberry have been discussed.*

*Nous avons établi la classification et la répartition du mûrier en Inde et au Japon. Nous avons décrit l'évolution de souches de mûrier améliorées en vue de l'exploitation commerciale, au moyen de la sélection conventionnelle, de l'obtention de polyplôides et des croisements de retour (backcross). Les maladies du mûrier que l'on rencontre couramment sont passées en revue.*

UTILIZATION OF DIFFERENT CARBON SOURCES BY A NEW ISOLATE  
OF MYROTHECIUM CAUSING LEAF SPOT OF MULBERRY

UTILISATION DE DIFFERENTES SOURCES DE CARBONE PAR UN NOUVEL  
ISOLAT DE MYROTHECIUM PROVOQUANT DES TÂCHES SUR LES FEUILLES DE MURIER

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The effect of different carbon compounds viz., starch, L-arabinose, D-glucose and L-rhamnose on the growth of Myrothecium mori sp. nov. has been studied. The fungus has been shown to cause leaf spot disease in mulberry. The most preferentially utilized carbon source was D-glucose which induced maximum growth and sporulation in the fungus. Starch was the least preferred carbon source as growth as well as sporulation was poor in this carbon source.

In the routine culture media tried, the growth of the fungus was best in potato dextrose agar, followed by oat meal agar, carrot agar, and mulberry leaf decoction agar. There was very poor growth and no sporulation in Czapek (Dox) agar. The colony morphology varied with the medium.

Nous avons étudié l'effet de différents composés de carbone c'est à dire l'amidon, L-arabinose, D-glucose et L-rhamnose sur la croissance de Myrothecium mori sp. nov. On a démontré que le cham-pignon provoque la maladie des taches sur la feuille du mûrier.

Le D-glucose qui provoque la croissance et la sporulation maximale du champignon est la source de carbone préférentielle. L'amidon est la source de carbone la moins utilisée car la croissance et la sporulation sont faibles. Dans le milieu de culture utilisé, la croissance la plus élevée a été obtenue avec la gélose dextrose de pomme de terre suivie par la gélose d'avoine, la gélose de carotte et la gélose de décoction de feuille de mûrier. La croissance et la sporulation sont faibles dans la gélose Czapek (Dox). La morphologie de la colonie varie avec le milieu.

## INSECT AND MITE PEST - COMPLEX OF MULBERRY IN INDIA

### COMPLEXE PARASITAIRE, INSECTE-PUNAISE, DU MURIER EN INDE

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Sericulture is fast developing agro-industry in India and mulberry being food plant of silkworm Bombyx mori L. plays a vital role. Mulberry is grown in every State of India, in an area of 1,94,020 hectares with more than 31,83,000 trees. Various diseases and pests are responsible for the deterioration of leaf quality and decrease in yield which is the basis of mulberry silk industry. Through pest risk analysis of Indian and world pests reported on mulberry, 63 insects and 9 mite species are found injurious to mulberry in India. They are harming the plant attacking at root, shoot or eating away leaves and some of them are responsible to cause other injurious manifestations. Their management is essential keeping in view of the health of silkworm which is very sensitive, to even small traces of insecticidal/acaricidal residues.

La sériciculture est une branche agricole qui se développe rapidement en Inde et le mûrier qui est la plante nourricière du ver à soie Bombyx mori L. joue un rôle de toute première importance. Le mûrier est cultivé dans tous les Etats de l'Inde sur une superficie de 194 020 hectares ce qui représente plus de 3 183 000 arbres. Diverses maladies et parasites sont responsables de la baisse de la qualité des feuilles et de la diminution du rendement, lequel est à la base de l'industrie de la soie mûrier. Par l'analyse des risques dus au parasitisme, on a dénombré 63 insectes et 9 espèces de punaises nuisibles pour le mûrier en Inde, parmi les parasites connus dans le monde et en Inde. Ils endommagent la plante en attaquant la racine, la tige ou en dévorant les feuilles et certains d'entre eux sont la cause d'autres dégâts. Leur contrôle est essentiel, sans perdre de vue la santé du ver à soie qui est très sensible aux résidus insecticides ou acaracides même en quantités infimes.

PRELIMINARY STUDIES ON THE EVALUATION OF NEW PROMISING  
INDEGENOUS STRAINS OF MULBERRY

ETUDES PRELIMINAIRES SUR L'EVALUATION DE NOUVELLES  
SOUCHES INDIGENES DU MURIER

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(Abstract non received yet)  
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XIVe CONGRES SERICICOLE INTERNATIONAL  
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SECTION BOMBYX MORI  
BOMBYX MORI SECTION

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LIU SHI XIAN

Identification on the resistance of silkworm (Bombyx mori) races to six types of silkworm disease. (*Résistance des races de vers à soie (Bombyx mori)...*) 377

K. PERIASAMY and S. RADHAKRISHNAN

Performance of an exotic Chinese polyvoltine silkworm Bombyx mori L. (Guang-nong-3) and its bivoltine hybrids in Tamil Nadu State. (*Performance d'une race exotique chinoise polyvoltine de ver à soie Bombyx mori L. ...*) 383

Y. MANO

Studies on the breeding of autosexing silkworm races in Japan. (*Etudes sur la sélection de races de ver à soie autosexables au Japon*). 389

R.K. DATTA

Improvement of silkworm races (Bombyx mori L.) in India. (*Amélioration des races de vers à soie (Bombyx mori) en Inde*). 393

S. UEDA

Popularization of the cooperative rearing for young silkworm with artificial diets and the prospective problems. (*Vulgarisation de la coopération d'élevage pour les jeunes vers à soie nourris sur aliments artificiels*). 417

M.N. NARASIMHANNA

Silkworm seed organization vital for sound sericulture in tropical countries. (*L'organisation du grainage du ver à soie est vital...*) 421

I.K. PAI and N.B. KRISHNAMURTHY

Effect of a growth promoter in multivoltine and bivoltine races of silkworm Bombyx mori. (*Effet d'un promoteur de croissance...*) 429

P.J. RAJU and N.B. KRISHNAMURTHY

Evolution of high yielding multivoltine races of silkworm Bombyx mori by selective hybridization. (*Evolution des races multivoltines de ver à soie...*) 430

GEETHABALI and M.V.V. SUBRAMANYAM

Studies on some mechanosensitive hairs on the ovipositor of the silkworm Bombyx mori. (*Etude du rôle de quelques soies mécanosensitives sur l'oviposition chez le ver à soie Bombyx mori*). 431

G. SREERAMA REDDY, N.B. KRISHNAMURTHY and G. SUBRAMANYA

Synthesis of new multivoltine breeds of silkworm Bombyx mori for tropical climates. (*Synthèse de nouveaux hybrides multivoltins de vers à soie Bombyx mori*). 432

G. SREERAMA REDDY and S.R. ANANTHAN NARAYANA

Evolution of new multivoltine strain of silkworm (Bombyx mori L.) with sex limited larval markings. (*Evolution d'une nouvelle souche multivoltine...*) 434

N.S. SIDHU

Indian environment - Tropical environment and sericulture. (*Environnement indien - L'environnement tropical et la sériciculture*). 436

G.S. RAJANNA, N.B. KRISHNAMURTHY and V. VASUDEV

Studies on the evaluation of two races of silkworm Bombyx mori for toxicity and mutagenicity of Zineb. (*Etudes de la toxicité et de la mutagenicité du Zineb sur deux races de ver à soie Bombyx mori*). 43B

N.S. SIDHU

Performance of the C.S.R.T.I. I to VIII multivoltine breeds of silkworm Bombyx mori L. for tropics. (*Performance des races de ver à soie Bombyx mori multivoltins I à VIII du C.S.R.T. sous les tropiques*). 440

B.M. SEKHARAPPA

Preliminary studies on the artificial hatching of bivoltine eggs of silkworm Bombyx mori by chemical method. (*Etudes préliminaires sur l'éclosion artificielle...*) 441

IDENTIFICATION ON THE RESISTANCE OF SILWORM  
(BOMBYX MORI) RACES TO SIX TYPES OF SILKWORM DISEASE

RESISTANCE DES RACES DE VERS A SOIE (BOMBYX MORI) A SIX  
MALADIES DU VER A SOIE

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The resistance of 33 silkworm races to cytoplasmic polyhedrosis virus (CPV), nuclear polyhedrosis virus (NPV), densovirus (DNV), pebrine, *Bacillus thuringiensis* (Bt) and sodium of fluoride (NaF) have been determined in 1978-1981. It has been found that the difference of resistance between the most highly resistant race and the most susceptible race were 2000-fold, 875-fold, 100,000-fold, 1000-fold, 134-fold and 40-fold respectively. This result provides resistant sources for the breeding races which have resistance to silkworm disease, such as resistant races to CPV (Nong42, Nong51, Yongdaizo etc.), resistant races to NPV (Hainan, Guobai, Qinjing etc.), resistant races to DNV (7201, 115nan, Yue5 etc.) and resistant race to pebrine (Baipidan). Some races have resistance to several silkworm diseases, for example, Yue5 has resistances to NPV, CPV, DNV, pebrine and NaF; Baipidan has resistances to CPV, DNV, pebrine, Bt and NaF.

Nous avons déterminé entre 1978 et 1981 la résistance de 33 races de vers à soie au virus de la polyédrose cytoplasmique (CPV), au virus de la polyédrose nucléaire (NPV), au densovirus (DNV), à la pébrine, à *Bacillus thuringiensis* (Bt) et au fluorure de sodium (NaF). Nous avons découvert que la race la plus résistante est respectivement pour chaque maladie, 2000, 875, 100 000, 1000, 134 et 40 fois plus résistante que la race la plus sensible aux maladies. Ceci permet d'avoir un réservoir de différentes résistances pour les élevages de races qui ont présenté déjà des résistances aux maladies telles que CPV (Nong42, Nong51, Yongdaizo etc.), NPV (Hainan, Guobai, Qinjing etc.), DNV (7201, 115nan, Yue5 etc.), pébrine (Baipidan). Certaines races sont résistantes

à plusieurs maladies, par exemple, Yue5 est résistante au NPV, CPV, DNV, à la pébrine et au NaF. Baipidan est résistante au CPV, DNV, à la pébrine, au Bt et au NaF.

## INTRODUCTION

China is the original place of silkworm, *Bombyx mori*. In several thousand years, there are many silkworm races which have been differentiated. Some researches reported that the strain difference of the silkworm in the resistance to each silkworm disease is very distinct. In order to find out the resistance of races to main silkworm diseases in sub-tropical and tropical areas, a study was made in 1978-1981.

## MATERIALS AND METHODS

### 1. Silkworm races

There were 33 tested races. They were divided into three groups. Group I included 12 bivoltine races, such as 8301, New 9, Su 12, Dong 34, and 306 etc.. Group II included 11 multivoltine races with diapause egg, such as Dai 09, Nong 42, Yongdaizo etc.. Group III included 10 multivoltine races with non-diapause egg, such as Hainang, Yue 5, Qinjing, Baipidan, 115 Nan etc..

### 2. Pathogens and their inoculum concentration

They are presented in table 1.

Table 1. Pathogens and their inoculum concentration.

| Pathogeny of silkworm diseases | Abbreviation | Inoculum concentration                                       |
|--------------------------------|--------------|--------------------------------------------------------------|
| Nuclear polyhedrosis virus     | NPV          | $3.3 \times 10^5$ to $1.1 \times 10^8$<br>(Polyhedra per ml) |
| Cytoplasmic polyhedrosis virus | CPV          | $3.4 \times 10^5$ to $1.0 \times 10^8$<br>(Polyhedra per ml) |
| Densovirus                     | DNV          | $10^{-2}$ to $10^{-5}$                                       |
| Pebrine spores                 | PS           | $10^3$ to $10^6$<br>(Spores per ml)                          |
| Bacillus thuringiensis         | Bt           | 10 to 1000 ppm                                               |
| Sodium of fluoride             | NaF          | 10 to 10000 ppm                                              |

### 3. Method for resistance determination

All these pathogens were respectively administered with mulberry leaves to the larvae. NPV, CPV, and DNV are infected at the 4th instar. Pebrine spores, *Bacillus thuringiensis*, and NaF toxicosis are infected at the 5th instar. According to the incidences of each silkworm disease, the infected concentration-50 (IC50) was estimated. Consequently, the resistance of silkworm races to the silkworm diseases were determined by IC50.

## RESULTS AND DISCUSSION

Results are summarized in Table 2.

The results (Table 2) indicated that there was a large variation for the resistance among the silkworm races. The difference of resistance of the silkworm races to each silkworm disease are presented as follows:

#### 1. The resistance to nuclear polyhedrosis virus

Among the 33 tested silkworm races, the most highly resistant races are Guobai, Hainan, Qinjing and Yangjing etc.. The susceptible races are 306, Dong34, 7307, 7306, and 7302 etc.. There are about 875-fold of resistance difference between the most highly resistant race and most susceptible race.

#### 2. The resistance to cytoplasmic polyhedrosis virus

In the case of this experiment, the most highly resistant races are Nong42, Nong51, Yongdaizo, Wu1, and Dai09 etc.. All of them are multivoltine green cocoon races in Guangdong province. The susceptible races are 7305, 8301, 7301, 7308 and 7307 etc.. There are about 2000-fold of resistance difference between the most highly resistant race and the most susceptible race.

#### 3. The resistance to densovirus

There are marked difference among the silkworm races. For the most highly resistant races such as 115 Nan, Yue5, Qujing and 7201 etc., the IC50 is  $10^1$ , it means the original DNV solution (1 gr midgut of DNV infected larvae added 3ml distilled water). However, for the most susceptible races, such as 7308, 8301, New9 and Wu1 etc., the IC50 only is  $10^{-5}$  to  $10^{-6}$ .

#### 4. The resistance to pebrine

Generally, the resistance difference among the races is not significant. Only the Baipidan race had special resistance, the IC50 is  $10^6$  spores per ml. The IC50 of most races is about  $10^4$  spores per ml.

#### 5. The resistance to *Bacillus thuringiensis*

There is a little difference of resistance among the tested silkworm races. The higher resistant races are Wu1, Yangjing etc. (IC50 = 120-134 ppm). Most of the tested races are susceptible (IC50 = 1-10 ppm).

#### 6. The resistance to sodium of fluoride

There is about 40-fold of resistance difference between the most highly resistant race and the most susceptible race. The higher resistant races are Yue5, Baipidan and 107 etc..

Table 2. The resistance to six types of the silkworm  
among 33 tested silkworm races.

| Group of<br>races | Name of<br>races | Infected concentration 50 (IC50) |                             |             |                            |             |              |
|-------------------|------------------|----------------------------------|-----------------------------|-------------|----------------------------|-------------|--------------|
|                   |                  | NPV<br>( $\times 10^6$ /ml)      | CPV<br>( $\times 10^6$ /ml) | DNV         | PS<br>( $\times 10^4$ /ml) | Bt<br>(ppm) | NaF<br>(ppm) |
| I                 | 306              | 04                               | 55.0                        | $10^{-3.2}$ | ---                        | 40          | 116          |
|                   | 7308             | 6.8                              | 0.5                         | $10^{-6.5}$ | 1.6                        | 10          | 19           |
|                   | Dong34           | 0.7                              | 2.2                         | $10^{-4.6}$ | 0.8                        | 10          | 98           |
|                   | New9             | 3.7                              | 1.3                         | $10^{-5.8}$ | 1.0                        | 10          | 633          |
|                   | 683              | 2.6                              | 0.5                         | ---         | 1.0                        | 10          | ---          |
|                   | 8301             | 15.0                             | 0.3                         | $10^{-6.0}$ | 2.4                        | 10          | 206          |
|                   | 7301             | 13.0                             | 0.4                         | $10^{-4.5}$ | ---                        | 10          | 134          |
|                   | Su12             | 3.9                              | 2.6                         | $10^{-3.7}$ | 0.7                        | 1           | 53           |
|                   | 7306             | 2.5                              | 10.0                        | $10^{-3.8}$ | 0.5                        | 1           | 116          |
|                   | 7302             | 3.4                              | 2.5                         | $10^{-3.8}$ | 1.0                        | 1           | 66           |
|                   | 7307             | 1.0                              | 0.5                         | $10^{-5.2}$ | 1.0                        | 1           | 30           |
|                   | 7305             | 6.5                              | 0.1                         | $10^{-5.0}$ | 1.2                        | 1           | 42           |

|     |           |     |     |             |       |     |     |
|-----|-----------|-----|-----|-------------|-------|-----|-----|
| II  | Wul       | 25  | 150 | $10^{-5.0}$ | 0.6   | 134 | 365 |
|     | 107       | 50  | 5   | $10^{-4.0}$ | 6.0   | 26  | 693 |
|     | 137       | 5   | 10  | $10^{-1}$   | 1.5   | 38  | 452 |
|     | Dong107   | 15  | 4   | $10^{-4.1}$ | 0.5   | 28  | 77  |
|     | Nong42    | 68  | 200 | $10^{-2.6}$ | 2.0   | 25  | 126 |
|     | 7201      | 90  | 5   | $10^1$      | 0.8   | 22  | 566 |
|     | Nong51    | 21  | 200 | $10^{-4.1}$ | 2.0   | 12  | 490 |
|     | 403       | 34  | --- | $10^{-4.1}$ | 4.5   | 13  | 230 |
|     | Dai09     | 90  | 150 | $10^{-3.5}$ | 8.0   | 16  | 140 |
|     | Yongdaizo | 28  | 200 | $10^{-3.5}$ | 1.0   | 13  | 271 |
| III | Autum303  | 45  | 4   | $10^{-4.1}$ | 2.0   | 17  | 30  |
|     | Yanjing   | 173 | 7   | $10^{-2.3}$ | 5.0   | 120 | 495 |
|     | Guobai    | 300 | 9   | $10^{-5.0}$ | 0.1   | 79  | 30  |
|     | Baipidan  | 43  | 53  | $10^{-1.5}$ | 100.0 | 79  | 755 |
|     | 9 Baihai  | 40  | 28  | $10^{-4.0}$ | 0.3   | 50  | 114 |
|     | 115 Nan   | 48  | 80  | $10^1$      | 0.6   | 46  | 253 |
|     | Bailezhou | 88  | 15  | $10^{-1}$   | 0.8   | 35  | 352 |
|     | Guohua    | 50  | 5   | $10^{-4}$   | 0.1   | 15  | 140 |
|     | Yue5      | 170 | 90  | $10^1$      | 10.0  | 12  | 773 |
|     | Hainan    | 333 | 35  | $10^{-1.6}$ | 0.8   | 18  | 215 |
|     | Qinjing   | 200 | 100 | $10^1$      | 0.9   | 19  | 495 |

The results indicated that the resistance of some silkworm races to one type or several types of the silkworm diseases are very strong. So, it is possible to breed new resistant races to silkworm diseases.

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PERFORMANCE OF AN EXOTIC CHINESE POLYVOLTINE SILKWORM  
BOMBYX MORI L. (GUANGNONG-3) AND ITS BIVOLTINE HYBRIDS  
IN TAMIL NADU STATE

PERFORMANCE D'UNE RACE EXOTIQUE CHINOISE POLYVOLTINE DE VER A SOIE  
BOMBYX MORI L. (GUANGNONG-3) ET DE SES HYBRIDES BIVOLTINS DANS  
L'ETAT DU TAMIL NADU

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*The performance of a polyvoltine white cocoon producing Chinese race of Bombyx mori (Guangnong-3) recently introduced in Tamil Nadu State, India, has been studied. This race as well as its cross breeds with bivoltine races has proved superior in several respects to the Pure Mysore Local and its bivoltine cross breeds hitherto reared in the State.*

*Nous avons étudié la performance d'une race chinoise polyvoltine à cocon blanc de Bombyx mori (Guangnong-3) récemment introduite en Inde dans l'Etat du Tamil Nadu. Cette race ainsi que les hybrides résultant de son croisement avec des races bivoltines se sont avérés très supérieurs, dans plusieurs domaines, à la race locale Pure Mysore et à ses croisements bivoltins élevés jusqu'à présent dans l'Etat.*

INTRODUCTION

The domesticated Bombyx mori L. is extremely sensitive to the environment and hence selection and improvement of silkworm races suitable to particular locations is one of the most important activities among other for improving sericulture. Under a research project entitled "Improvement of sericulture in Tamil Nadu", the first author who is the Principal Investigator had the opportunity of visiting China in June 1983 to observe the practice of sericulture there and gather first hand knowledge. He found that as in Tamil Nadu, bivoltine races of silkworm could not be sa-

tisfactorily reared in the warm sub-tropical Guangnong province of Southern China in spite of their best efforts and so they reared only polyvoltines in this region. Since Tamil Nadu State is on the whole much hotter than Southern China it was clear that bivoltines could not be successfully reared in the state and so only a good polyvoltine would prove to be an asset. Not only can a high temperature tolerant polyvoltine be reared as such but also it can be crossed with bivoltines since such cross breeds are capable of giving better performance than the pure bivoltines even under hot climatic conditions. In this regard it was further significant that the Chinese has established excellent polyvoltines producing white cocoons unlike the prevalent Indian ones that produce yellow, flossy cocoons of inferior quality. Furthermore the cross with bivoltines will produce the more valuable white cocoons unlike cross breeds with the local polyvoltine that produce yellow cocoons due to the dominance of yellow colour.

The Chinese were kind enough to accede to the request of the author for a high temperature adapted polyvoltine and provided him at the time of his departure from Gungzou, about 50 F1/DfLs (of strains 137 x 303) of a polyvoltine variety Guangnong-3. The present article deals with the relatively superior performance of this race and its crossings with bivoltines in Tamil Nadu.

#### MATERIALS AND METHODS

As stated in the introduction, 50 F1 DfLs of Guangnong-3, which will hereafter be mentioned as GN3, were brought from China in June 1983 by Dr. K. Periasamy. DfLs of Pure Mysore were purchased from the Department of Sericulture, Government of Tamil Nadu. DfLs of the remaining combinations of hybrids of GN3 with bivoltine and polyvoltine races were prepared in our laboratory. Silkworms were reared on mulberry leaves following the method of "New Technology of Silkworm Rearing" (S. Krishnaswami, 1979). Field performance of GN3 was studied by distributing chawkie silkworms to four places around Tiruchirapalli. Comparative performance of pure races and hybrids was studied by brushing all combinations with a difference of two days only. The rearings were made at our laboratory on mass scale with ten to fifteen layings for each of the combinations.

Observations were made on hatching percentage, larval duration, moulting period, single cocoon weight, shell weight, shell ratio, length of filament, denier, reelability, effective rate of rearing (ERR) and fecundity. Length of filament reelability and denier were determined according to the standard method given in FAO Agricultural Services Bulletin 15/3 (S. Krishnaswami *et al.*, 1972).

#### RESULTS AND DISCUSSIONS

Table 1 gives the data of the observations on the economic characters. The results are discussed below :

##### Larval duration :

GN3 had the shortest larval duration i.e. 18 days as it had in China. Its hybrids with both NB4D2 and KA has almost the same larval period i.e., about 22 days which is 2 to 3 days shorter than the larval period of Pure Mysore x KA, a cross breed commonly reared in Tamil Nadu, whereas the difference was 5 to 6 days in the cross of GN3 and Pure Mysore. Similarly in the total moulting period also a notable difference was seen, the shortest being that of GN3 and the longest that of Pure Mysore x KA.

|                             |        | June-July 83<br>Guangnong-3 | June-July 83<br>Pure Mysore<br>(Local) | August-Sept. 83<br>Pure Mysore<br>(Local) x<br>Guangnong-3 | August-Sept. 83<br>Guangnong-3<br>x NB402 | August-Sept. 83<br>Guangnong-3<br>x KA | August-Sept. 83<br>Pure Mysore<br>(Local) x KA |
|-----------------------------|--------|-----------------------------|----------------------------------------|------------------------------------------------------------|-------------------------------------------|----------------------------------------|------------------------------------------------|
| Hatching (%) (n* = 10)      |        | 89 ± 2.7                    | 93.6 ± 5.8                             | 95.6 ± 1.5                                                 | 93.8 ± 0.78                               | 95.3 ± 1.6                             | 95.2 ± 2.0                                     |
| Total larval period (days)  |        | 18                          | 23-24                                  | 23-24                                                      | 22-23                                     | 21-22                                  | 24-25                                          |
| Total moulting period (hrs) |        | 80-85                       | 90-95                                  | 88-93                                                      | 92-97                                     | 90-96                                  | 95-102                                         |
| 1 Single cocoon weight      | Female | 979 ± 50                    | 902 ± 37                               | 1086 ± 74                                                  | 1376 ± 136                                | 1363 ± 131                             | 1322 ± 37                                      |
|                             | Male   | 773 ± 28                    | 766 ± 41                               | 854 ± 93                                                   | 1166 ± 50                                 | 1178 ± 77                              | 1144 ± 13                                      |
| 1 Single shell weight       | Female | 168 ± 11                    | 98 ± 6                                 | 134 ± 12                                                   | 253 ± 19                                  | 237 ± 20                               | 214 ± 8                                        |
|                             | Male   | 162 ± 12                    | 96 ± 7                                 | 127 ± 15                                                   | 238 ± 27                                  | 233 ± 17                               | 208 ± 9                                        |
| 1 Silk ratio percentage     | Female | 17.1 ± 0.4                  | 10.8 ± 0.5                             | 12.3 ± 0.5                                                 | 18.3 ± 1.5                                | 17.4 ± 1.5                             | 16.1 ± 0.5                                     |
|                             | Male   | 20.9 ± 0.9                  | 12.5 ± 1.0                             | 14.8 ± 0.5                                                 | 20.4 ± 1.4                                | 19.8 ± 0.6                             | 18.2 ± 0.6                                     |
| Average length of filament  |        | 740 ± 50                    | 211 ± 16                               | 502 ± 18                                                   | 1057 ± 43                                 | 1032 ± 27                              | 690 ± 25                                       |
| Denier                      |        | 1.6 to 1.8                  | 1.7 to 2.0                             | 1.7 to 1.9                                                 | 1.9 to 2.2                                | 1.9 to 2.2                             | 2.0 to 2.2                                     |
| Reelability (%)             |        | 89                          | 45                                     | 74                                                         | 92                                        | 92                                     | 75                                             |
| ERR (%)                     |        | 81                          | 77                                     | 84                                                         | 84                                        | 84                                     | 83                                             |
| Fecundity No. (n* = 20)     |        | 382 ± 31                    | 360 ± 43                               | ---                                                        | ---                                       | ---                                    | ---                                            |

\* Number of DFLs

1 Mean values represent the average of 50 samples

Table 1. Data on the performance of the Chinese race Guangnong-3 (*Bombyx mori* L.) and its bivoltine cross breeds at tiruchirapalli.

#### Single cocoon weight :

The hybrids GN3 x NB4D2 recorded the highest shell weight of 253 and 238 mg for female and male respectively. Single shell of GN3 x KA was 11 % higher than L x KA ( $P = < 0.01$ ). In the polyvoltines the shell of GN3 was 70 % higher than that of Pure Mysore ( $P < 0.001$ ).

#### Shell ratio :

GN3 x NB4D2 showed the highest shell ratio which was about 12 % higher than that of L x KA while Pure Mysore showed the lowest shell ratio which was 39 % lower than GN3 ( $P < 0.001$ ).

#### Length of filament :

The filament length reeled from the cocoons of GN3 x NB4D2 and GN3 x KA measured about 1,050 metres whereas it was only 690 metres in L x KA which was 34 % lower. Among the polyvoltines the cocoons of GN3 yielded 250 % more than the Pure Mysore.

#### Denier :

There was almost no difference in the denier among the hybrid combinations but GN3 produced relatively finer filament, the denier ranging from 1.6 to 1.8.

#### Reelability :

The reelability was excellent in GN3 and its hybrids amounting to 89 to 92%. All the cocoons were free from floss with fine granulations, which are parameters that signify high rate of reelability. On the other hand Pure Mysore with its highly flossy and loose cocoons has a poor reelability of only about 45%. The reelability of Pure Mysore x GN3 and that of Pure Mysore x KA was better, amounting to 75%.

#### Effective rate of rearing (ERR) :

It was of interest to note that hybrids of GN3 showed a high percentage of ERR ranging from 81 to 84 % for 10,000 larvae brushed in the very first batch of their rearing in Tamil Nadu. In field trials, the yield of cocoons for 10,000 chawkie silkworms distributed ranged as high as 96 to 98 %.

#### Fecundity :

The laying capacity and fecundity of GN3 was nearly as much as Pure Mysore, the number of eggs per layings being about 382.

#### Hatching percentage :

In all the cases, the hatching percentage was almost the same, and the slightly lower hatching of GN3 (89%) was perhaps due to transportation of the layings from China.

#### Field trial performance of GN3 :

The results of the trial rearing carried out during June-July 1983 around Tiruchirapalli district given in Table 2 clearly showed that GN3 was able to withstand a high temperature ranging from 33 to 38°C. Encouraging results were obtained with regard to yield of cocoons for 10,000 larvae supplied after III moult out. In three places, single cocoon weight and shell ratio were more or less similar to what was obtained in our laboratory. In one place (Musiri), however, these parameters were significantly poor and biochemical analysis of mulberry leaves taken from this garden showed that the leaves were very poor in nutritive substances as estimated from chlorophyll content (Periasamy *et al.*, 1984) and this evidently caused the decrease in

| Season                                            | Place          | Larval duration<br>(days) | Yield of cocoons<br>for 10,000 larvae<br>out of III moult | Single cocoon<br>weight (mg) | Shell weight<br>(mg) | Shell ratio<br>(%) |
|---------------------------------------------------|----------------|---------------------------|-----------------------------------------------------------|------------------------------|----------------------|--------------------|
| (Mean value represents the average of 50 samples) |                |                           |                                                           |                              |                      |                    |
| June-July 1983                                    | Uppiliapuram   | 18                        | 9875                                                      | 896 ± 79                     | 156 ± 14             | 17.5 ± 2.1         |
| June-July 1983                                    | Mathur         | 18                        | 9719                                                      | 782 ± 80                     | 142 ± 10             | 18.2 ± 2.1         |
| June-July 1983                                    | Musiri         | 18-19                     | 9637                                                      | 533 ± 96                     | 66 ± 10              | 12.5 ± 1.6         |
| June-July 1983                                    | Mannachanallur | 18                        | 9787                                                      | 881 ± 113                    | 164 ± 11             | 18.6 ± 1.8         |

Table 2. Field trial performance of the Chinese race Guangnong-3 (*Bombyx mori* L.) around Tiruchirapalli.

single cocoon weight and shell weight. But it was significant that in spite of this poor nutrition there was no reduction in the ERR.

#### Large scale rearing performance :

About 12,000 cocoons of GN3 harvested from the layings brought from China were handed over to the Tamil Nadu State Sericulture Department for proper selection and large scale preparation of layings for distribution to different centres.

A total of 3,455 layings were prepared by the Department out of which 2,250 were crosses with bivoltines. The layings were distributed to almost all the districts to find out the suitability of the race and its behaviour.

The best result was received from Tirunelveli district in spite of the temperature of as much as 38°C that prevailed at that time. The average ERR was about 90%. The average silk content of the batch was 18% for the cross breed and 17.7% for the selected inbred batch. The filament length of GN3 was 750 metres.

On the whole, the race GN3 has proved to be a very successful race in Tamil Nadu with better qualities in almost all sericultural parameters, compared to the Local Mysore and its hybrids with bivoltines hitherto used for commercial rearing in the state. The Tamil Nadu Department of Sericulture has taken up the further breeding and distribution of this race with great enthusiasm.

#### ACKNOWLEDGEMENT

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## STUDIES ON THE BREEDING OF AUTOSEXING SILKWORM RACES IN JAPAN

### ETUDES SUR LA SELECTION DE RACES DE VER A SOIE AUTOSEXABLES AU JAPON

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*This paper deals with the breeding process and features of silkworm races with sex-limited larval marking and those spread in Japan. The most striking characteristic of such sex-limited silkworm races is the easiness of sex discrimination. Newly bred sex-limited silkworm races were superior to ordinary silkworm races in raw silk percentage of cocoon and percentage of degumming loss of cocoon shell. In 1983, spread rates of sex-limited silkworm races were approximately 50 % in spring rearing season and 40 % in summer and autumn rearing seasons, respectively.*

*Cet article traite de la procédure de l'élevage et des caractéristiques des races de ver à soie marquées selon le sexe et des races généralement élevées au Japon. La caractéristique la plus frappante des races de ver à soie marquées selon le sexe est la facilité avec laquelle on distingue les sexes. Les nouvelles races de ver à soie marquées sont supérieures aux races ordinaires du point de vue de la richesse soyeuse et de la perte au décreusage de la coque. En 1983, 50% des vers de l'élevage de printemps et 40% des vers de l'élevage d'été et de l'élevage d'automne étaient des vers à soie sexuellement marqués.*

The silkworms usually reared in the farms in Japan are all  $F_1$  hybrids. To obtain these  $F_1$  hybrids, the parent silkworms must be separated into male and female silkworms before they become moths so that they do not copulate freely. Sex discrimination has hitherto been done by macroscopic observation of the primordia of the reproductive organs of the larva or pupa or by using the difference in the weight of the male and female silkworm cocoons. These methods, however, require special skill and

much labor, and what is more, the sex of some of the parent strains are difficult to discriminate. Therefore, the practical use of silkworm species with sex-limited characters whose sex can be easily discriminated has long been awaited.

The species with sex-limited characters is produced by translocating the gene for distinguishing males from females from autosomes onto the W chromosome which only the female has. Dr. Tazima first produced the sex-limited "sable" silkworm by X-ray irradiation in 1941. Thereafter, he discovered the sex-limited "normal marking" and "moricaud" as mutants from sex-limited "sable". Furthermore, in 1953, Dr. Sasaki discovered the silkworms with sex-limited "black" and new "normal marking" as mutants from sex-limited "moricaud". As other species with sex-limited characters, there were reported to be sex-limited "zebra" by Hashimoto, sex-limited "black egg" by Tazima and Harada, and sex-limited "yellow cocoon" by Kimura and Harada.

Among them, silkworms with sex-limited new "normal marking" and "yellow cocoon" have few physiological disorders considered to be due to the chromosome translocation and the former is being used as a practical species and the latter is being improved for practical uses.

The species of silkworms with sex-limited new "normal marking", J131 x C131, was designated as the practical species with sex-limited characters in 1967 as a result of our efforts. This species was more vigorous and yields more cocoons than the control species without sex-specific characters, J124 x C122 (Futo). It was also superior in good reelability and low degumming loss of cocoon shell.

This species has been used for breeding materials in prefectural research facilities and private laboratories, as well as at the Sericultural Experiment Station. Eighteen of the 34 hybrid species for spring rearing and 14 of the 33 hybrid species for summer and autumn rearing have sex-limited characters at the present time. Four of these species have sex-limited characters for both Japanese and Chinese species (species with sex-limited characters for both parent). All of the other species have sex-limited characters for only the Chinese species (species with sex-limited characters for only one parent). The species with sex-limited characters for both parents, J140 x C145, which was bred by us and registered in 1979, and the most widely used species with sex-limited characters for only one parent, Asa.Hi x Tou.Kai, which was bred by Dr. Tazima, showed a high raw silk percentage of cocoon and low percentage of degumming loss of cocoon shell. The use of the species with sex-limited spots is spreading reaching 40% in 1983.

The species with sex-limited "yellow cocoon" was produced in 1971 using gamma radiation. It has few physiological abnormalities due to chromosomal translocations, and its characteristics are now being improved. When the sex-limited "yellow cocoon" is put to practical use, the distinguishment of male and female silkworms will become more efficient and another accompanying merit such as the possibility of separate reeling of male and female silkworm cocoons may be expected.

Table 1. Results of rearing and silk reeling in the autosexing silkworm races

| Name of<br>races               | Duration<br>of feeding<br>period | Percentage<br>of pupation | Amount of<br>cocoon crop<br>per ten<br>thousand<br>larvae | Raw silk<br>percentage<br>of cocoon | Length of<br>cocoon<br>filament | Reelability<br>of cocoon | Neatness<br>defects | Degumming<br>loss per-<br>centage | Year<br>designated |
|--------------------------------|----------------------------------|---------------------------|-----------------------------------------------------------|-------------------------------------|---------------------------------|--------------------------|---------------------|-----------------------------------|--------------------|
|                                | (day, hr)                        | (%)                       | (Kg)                                                      | (%)                                 | (m)                             | (%)                      | (point)             | (%)                               |                    |
| J.131* x<br>C. 131*            | 23.20                            | 96.8                      | 20.5                                                      | 20.16                               | 1236                            | 76                       | 94.7                | 23.9                              | 1967               |
| J.124 x<br>C.122F<br>(control) | 24.02                            | 96.5                      | 20.1                                                      | 19.80                               | 1336                            | 72                       | 94.8                | 25.8                              | "                  |
| J.140* x<br>C.145*             | 24.06                            | 95.9                      | 22.1                                                      | 21.69                               | 1504                            | 73                       | 95.3                | 23.3                              | 1979               |
| J.134 x<br>C.135<br>(control)  | 24.03                            | 96.1                      | 22.8                                                      | 20.84                               | 1426                            | 78                       | 95.4                | 25.2                              | "                  |
| Asa.Hi x<br>To*.Kai*           | 23.23                            | 95.2                      | 21.0                                                      | 21.81                               | 1478                            | 72                       | 95.3                | 24.8                              | 1976               |
| J.134 x<br>C.135<br>(control)  | 23.17                            | 95.7                      | 21.4                                                      | 20.84                               | 1415                            | 73                       | 95.0                | 25.5                              | "                  |

\* An asterisk indicates the autosexing silkworm race.

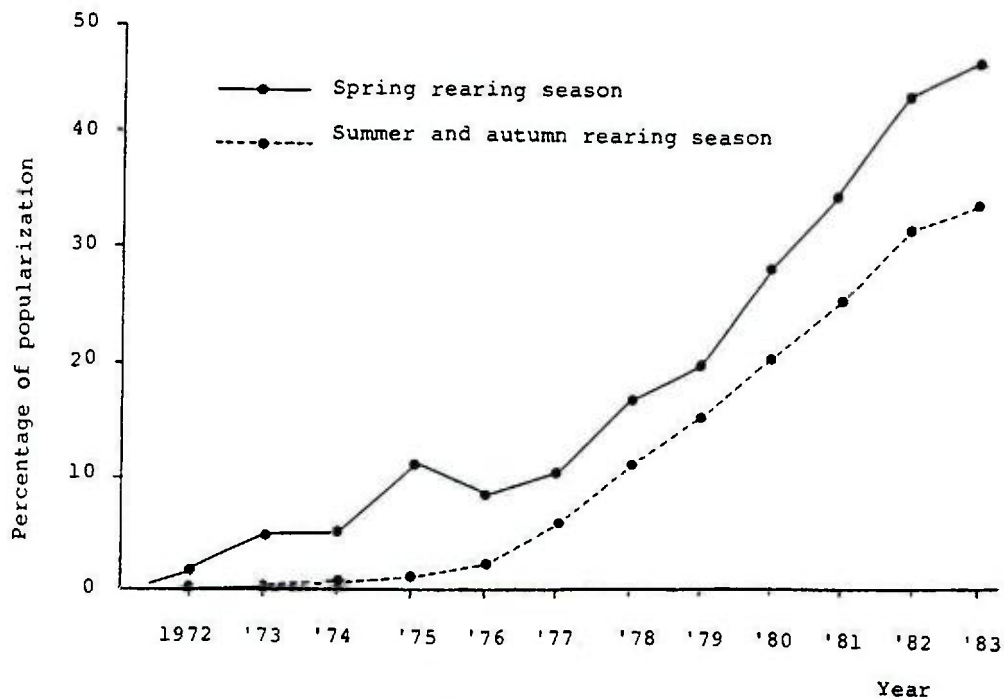


Fig. 1 Popularization of autosexing silkworm races for practical cocoon production

IMPROVEMENT OF SILKWORM RACES (BOMBYX MORI L.)  
IN INDIA

AMELIORATION DES RACES DE VERS A SOIE (BOMBYX MORI L.) EN INDE

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Sericulture has been practised in India since time immemorial. Indigenous races of West Bengal, Jammu & Kashmir and Karnataka have been reared in the 19th-20th Century. However, poor yield and quality, lack of infrastructural support and appropriate rearing and seed technology came in the way for evolving high yielding multi-and bivoltine races.

During the seventies, Central Sericultural Research & Training Institutes (CSR&TI), Mysore (Karnataka) and Berhampore (West Bengal) evolved number of poly-and bivoltine races suitable to different agroclimatic conditions of tropics. The commercial hybrids of Pure Mysore and bivoltine breeds, which are popular with the farmers, increased the average cocoon production to 35 kg/100 dfls from 18-20 kg of traditional cross, Pure Mysore x C.Nichi in South India. The renditta too has now come down to 10 from 18 in the traditional crosses. This resulted in trebling of raw silk production in a decade's time apart from the spread of sericulture development programme to the non-traditional states in the country.

In the eighties, CSRTI, Mysore, started a bimodal approach to silkworm breeding with an aim to further improve polyvoltine as well as bivoltine breeds with specific needs for tropics. Performances of these new multi-and bivoltine breeds which are presently being field tested, are detailed in the paper. In the new bivoltine hybrids the cocoon yield/10,000 larvae and renditta have further improved to register a yield of 21 kg and 5.1, respectively. The author has also discussed in the paper the perspective breeding programmes apart from the need for international gene bank, and biometrical/biochemical genetic researches.

La sériciculture est pratiquée en Inde depuis des temps immémoriaux. Au 19ème et début du 20ème siècle, les sériciculteurs élevaient des races indigènes du Bengale occidental, du Jammu,

du Kashmir et du Karnataka. Cependant, le faible rendement, le manque d'infrastructure et de technologie d'élevage et de grainage ont empêché le développement des races bivoltines et multivoltines à fort rendement.

Au cours des années 1970, les Instituts de Formation et de Recherche Séréricole de Mysore (Etat de Karnataka) et de Berhampore (Bengale occidentale) ont développé un certain nombre de races bivoltines et polyvoltines adaptées aux conditions agroclimatiques des tropiques. Les hybrides commerciaux de Pure Mysore et de souches bivoltines qui sont très utilisées par les sériciculteurs ont permis d'atteindre une production moyenne de cocon de 35 kg/100 dfls alors que celle-ci ne dépassait pas 18-20 kg avec le croisement traditionnel, Pure Mysore x C.Nichi utilisé dans le sud de l'Inde. Le rendement est passé de 18 (croisements traditionnels) à 10. Sans tenir compte de la mise en place des programmes de développement de la sériciculture dans les Etats où la sériciculture n'est pas une activité traditionnelle, la production de soie grège a triplé en 10 ans.

Dans les années 1980, le CSRTI de Mysore commença une approche bimodale de l'élevage du ver à soie visant à améliorer les races polyvoltines et les races bivoltines pour répondre aux besoins spécifiques des régions tropicales. Les performances de ces nouvelles souches multi et bivoltines qui sont testées en ce moment sont données en détail dans cet article. Les nouveaux hybrides bivoltins donnent 21 kg de cocons/10 000 larves soit un rendement de 5,1 ce qui représente une nette progression.

## INTRODUCTION

According to the archeological and bibliographical evidence sericulture was introduced in India in the 2nd century from China through Khotan. However, Indian scholars maintain that silkworm industry in India is as old as Indian culture. Ancient Hindu literatures e.g. Righveda, Ramayana, Mahabharatha have many references on the use of silk clothes and sericulture (Mukherjee 1899). According to Indian history, the silk was merchandised in Rome during the reign of Kanishka (58 B.C.). This business was also extended to middle east and South European countries in direct competition with China in ca 200 AD. Historical evidence also supports the fact that sericulture was the livelihood of many Indian people especially located in Kashmir and West Bengal during the "Mughal" period (16th and 17th centuries). But the industry subsequently suffered a set back on account of inadequate organization and outbreak of pebrine disease in mid nineteenth century as also due to direct competition of silk trade from Japan, China, France, etc.

Notwithstanding the fact that sericulture is practiced in India from time immemorial, nothing is known in particular about the characteristics of races except that the reared silkworms produced white and coloured cocoons. Prior to the British period (Eighteenth century), silkworm races were chiefly reproduced and maintained by egg producers.

Systematic breeding researches were initiated very late (early twentieth century), when various Government Institutions were set up to look into the problems of sericulture. In this paper, sincere attempts are made to detail the improvement of silkworm races suited to different agro-climatic conditions of tropics mostly using the data collected from various research Institutions of India.

## RACES USED PRIOR TO INTRODUCTION OF F1 HYBRIDS

### Barapolu

According to the record, it is the only indigenous univoltine race reared for a long time in West Bengal. The colour of the cocoons is greenish white. The race has now become extinct.

### Chotapolu

This is a multivoltine race, also reared for two centuries in West Bengal. Cocoons of this race are small, spindle shaped, flossy and white in colour. The race is no more available now.

### Nistari

This multivoltine race was introduced in West Bengal in the nineteenth century and thrived well in West Bengal climatic condition. Cocoons of this race are small, spindle shaped, flossy and golden yellow in colour. The shape, colour and behaviour of this race resemble the silkworm breed reared in Thailand. The race being highly resistant to diseases, is very much popular with the farmers of West Bengal and is reared in maximum quantity now.

### Bulupolu

It is an extinct multivoltine race once reared in West Bengal for a long time. Silkworms spin small and greenish cocoons.

### Sorupat

It is a multivoltine race reared in the North Eastern part of India (Assam, Mizoram and Meghalaya). Silkworm spin small, flossy, white or light green cocoons.

### Pure Mysore

This is a multivoltine race of Karnataka and other South Indian States and is very popular with the farmers. It is said to have originated in China and brought to India in 1875 during Tipu Sultan's period. As compared to other multivoltine races, its larval period is prolonged (28-29 days); and silkworms spin small, greenish and flossy cocoons.

### Kashmir race

It is an extinct race which once produced famous Kashmir silk. It is reported that Kashmir race was a univoltine silkworm breed having white and yellow cocoons, and was exported to Europe when European races were attacked by pebrine (Nanavathy, 1965).

### C. Nichi

This was originally a bivoltine race of Japan introduced in India during early twentieth century in the old Mysore State. But due to continuous rearing by the egg producers it has now converted into a multivoltine race. Its larval period is shorter than that of Pure Mysore, and silkworms spin white, dumbbell shaped small cocoons.

## UTILIZATION OF HYBRIDS

### A. Utilization of heterosis vigour for commercial rearing.

All these indigenous multivoltine races were reared commercially for hundreds

of years and thus deteriorated very much in respect of cocoon yield. Need for more useful races was, therefore, keenly felt and consequently hybrid era in sericulture industry in India commenced as early as 1922 in the old Mysore State (present name: Karnataka State) where crosses between indigenous Pure Pysore and Japanese races were popularized. Later on one combination, Pure Mysore x C. Nichi became very popular with the farmers (Nanavathy, 1965) and thus, the tradition of rearing hybrids instead of pure lines came to stay in South India.

F1 crosses between indigenous race, Nistari and exotic uni or bivoltine races were introduced in West Bengal since 1956. F1 era commenced in Jammu & Kashmir in 1959 when two important crosses from Japan viz: Taihei x Choan, and Hoko x Shugyoku were tried.

#### **B. Utilization of hybrids for breeding fixed races.**

With the availability of foreign races attempts were made in 1940 in West Bengal to improve the indigenous races, Nistari and Chotapolu by hybridizing with a few Italian races (Ghosh 1949). These races viz: Nistid, Nismo, Ichol, Itan were popular with the farmers and performed well except the rainy seasons. Their yield was better compared to that of Nistari and Chotapolu. But due to continuous rearing and poor selection, the races again degenerated and became extinct.

### **PROBLEMS IN SILKWORM BREEDING**

#### **A. Poor yield and quality of indigenous races.**

The performance of indigenous races are presented in Table 1. It will be clear from the data that all these multivoltine races are very poor with regard to cocoon yield, and fall far below the international standard for silk yarn. It is therefore apparent that a high yielding multivoltine race could hardly be evolved by exploiting these races.

#### **B. Lack of infrastructure.**

Another constraint that is posed earlier was the non-availability of research institutions for breeding work. Sporadic attempts were no doubt made to bring quality breeds or hybrids from temperate countries, but many races were either degenerated or became extinct for non-existence of qualified breeders and breeding institutions.

#### **C. Lack of appropriate rearing and seed technology.**

The sericulture industry in India suffered a lot in 19th and 20th centuries due to very poor standard of rearing. The care required for high yielding breeds during early and late silkworm larval stages, was completely unknown to the silkworm growers, while the egg producers were not aware of the technique of proper incubation, aestivation and hibernation.

### **ADVANCEMENT OF SILKWORM BREEDING IN INDIA WITH THE ESTABLISHMENT OF CENTRAL SERICULTURAL RESEARCH INSTITUTES**

To tackle the various field problems faced by the silk industry in South India, a full fledged Sericultural Research and Training Institute (CSR&TI) was established in 1961 at Mysore. Similarly, the Sericultural Research Station located at Berhampore (West Bengal) was reorganized in sixties decade to look into the problems of sericulture in Eastern India.

### 1. Appropriate rearing and seed technology for tropics.

Within a decade's endeavour, CSR&TI, Mysore, developed an appropriate rearing technique required for chawki worms (young age) as well as late age worms in tropical condition (Krishnaswami, 1972). Definite recommendations on the egg care (incubation, aestivation), acid treatments and hibernation schedule were made by the Institute for maintaining bivoltine races (Krishnaswami et al., 1976; Jolly, 1983).

### 2. Change in the concept of region specific breed utilization.

According to earlier concept multivoltine breeds are required for North Eastern India and Southern tropical regions, while exotic bivoltine breeds for Northern India (temperate zone). Thus CSR&TI, Berhampore and Mysore were organized for multivoltine breeds, whereas CSSS, Pampore (Kashmir), CSRS, Kalimpong (West Bengal) and SSS, Coonoor (Tamilnadu) were established to breed, maintain and supply bivoltine breeds.

With the successful rearing and seed technology developed by the Institute it became possible to evolve and popularize a few high yielding bivoltine races in the traditional multivoltine plateau of South India in the seventies decade. Of interest is that of the high yielding bivoltine races are now reared in much hotter zones of India, viz: Andhra Pradesh, Tamilnadu, Maharashtra, Rajasthan and Gujarat (Annual Reports of CSR&TI, 1981 to 83) and thus, the concept of region specific breed utilization has been changed completely.

### 3. Synthesis of new bivoltine breeds.

CSR&TI, in early seventies decade, had evolved two bivoltine breeds viz: KA and NB4D2 through hybridization and selection. This cross was named as Nandi race (KA x NB4D2) and was popularized in Karnataka State in mid seventies decade (Narasimhanna et al., 1976; Jolly, 1983). Later on two additional bivoltine breeds NB7 and NB18 were evolved and released in the field as Chamundi cross. The data on the performance in these races in South India are presented in Table 2.

A number of experiments have also been conducted at Regional Sericultural Research Station, Pampore (Kashmir) in recent years and the lines PLF, KY-1, BL-1 appear to be promising. But these breeds are yet to be popularized with the Kashmir farmers.

In most of the above efforts, the initial breeding material has been one or more number of commercial hybrids from abroad, which enabled in fixing high yielding material, rich in silk content through selection.

## RECENT APPROACH TO THE SILKWORM BREEDING IN INDIA

### A. Impact of new bivoltine breeds

Popularization of bivoltine breeds in South India resulted in progressive improvement of cocoon yield and quality of multivoltine hybrids. In fact, the new hybrid of Pure Mysore and new bivoltine breeds have almost completely replaced the old hybrids (Pure Mysore x C. Nichi and Pure Mysore x HS6) to the extent of 85%. Increase in total yield, cocoon weight, shell weight and filament length in the new multivoltine and bivoltine hybrids is presented in Fig. 1. Within a decade's time the production of silk yield in Karnataka has increased to 2900 tonnes (1980) from 1350 tonnes (1970). As an additional impact sericulture of traditional Karnataka plateau spread to non-traditional areas of Andhra Pradesh and Tamilnadu in a big way. These two States who were producing a negligible quantity of raw silk in late sixties decade are jointly producing now 1400 tonnes per year.

## B. New breeding approach for tropical region

It may be worth mentioning here that due to obvious reasons the present approach of silkworm breeding is different from that of breeders of temperate countries. Our main concentration is now towards the improvement of both multivoltine and bivoltine. In fact 85% of total cocoons produced in India comes from multi-bivoltine crosses.

### 1. Improvement of multivoltine indigenous races using bivoltine races:

In mid sixties and seventies decade a good number of multivoltine races are evolved at CSRTI, Mysore by crossing the Pure Mysore with bivoltine races with an aim to improve the cocoon yield and yarn quality. These races are Mysore Princes, Kolar gold, Kollegal Jawan, TEP<sub>2</sub>, NS<sub>4</sub> and Hosa Mysore. The performance of these breeds are presented in Table 3.

Similarly, CSRTI, Berhampore in seventies decade had evolved a number of multivoltine breeds by hybridization of Nistari female with bivoltine males. These are A4e, MBDIV, MBDV, D146, D3C (Krishnaswami et al., 1964) and O (Yellow), L (Yellow), L2+3, etc. (Sengupta and Datta, 1972). Rearing performances of these races are shown in Table 3.

Although large number of varieties were evolved and tried in the field for commercial exploitation, none of these races became popular with the sericulturists due to the recurrent occurrence of hibernated eggs. In fact the setback in the fixation of race is obvious due to utilization of bivoltine blood.

### 2. Improvement of multivoltine breeds utilizing indigenous blood only.

#### a) Mutation breeding

Realizing the difficulties in evolving the high yielding pure multivoltine breeds, CSRTI, Berhampore resorted to Mutation Breeding Technique. Datta et al. (1981) evolved a few promising multivoltine high yielding breeds, CB2, CB5, through isolation of irradiated and chemical mutagen treated lines and subsequently by hybridization of those lines and selection. In 1980 large quantity of hybrids of CB2 and CB5 were reared successfully in Malda and West Dinajpur districts of West Bengal. The performance of these lines are presented in Table 4.

CSRTI, Mysore has also improved the indigenous Pure Mysore through X-radiation and subsequent isolation of shorter larval period through selection (Iyengar et al., 1981). Comparative performance of Pure Mysore race, PMS<sub>2</sub> and PMX is presented in Table 5.

#### b) Evolution of multivoltine breeds for specific need

In 1981, CSRTI, Mysore has initiated a few new breeding plans to evolve multivoltine breeds with (a) shorter larval period and higher silk content, (b) high disease resistance, (c) better silk quality and higher silk yield. Under this programme existing indigenous races, Nistari, Pure Mysore and Sorupat and a few evolved breeds viz: Hosa Mysore, Mysore Princes, Kolar gold were utilized for synthesis of new breeds with specific characters. A few lines viz: MY<sub>1</sub>, MY<sub>2</sub>, MW<sub>1</sub> and MW<sub>2</sub> were already fixed and under field trial programme of the Institute. An average rearing performance of the lines as well as their hybrids with bivoltine is presented in Tables 6 and 7.

#### c) Sex-limited multivoltine breeds

In India, the male moths of multivoltine races are not used for raising hybrid layings since multivoltine females are only crossed with bivoltine males to get non-hibernated eggs. As a result 50% of multivoltine cocoons is wasted and those are not

available for reeling purpose. In late sixties, attempts are thus made to introduce sex limited larval markings in the multivoltine races both at CSRTI, Mysore and Berhampore. The source of the translocational strain was from a Russian breed Saniish 9 maintained at Central Silkworm Seed Station, Pampore (Sengupta, 1969). A few multivoltine breeds have been fixed by crossing the existing multivoltine breeds with the sex limited Saniish 9. These races are Nistari (S.L.), D14b (S.L.), MBD IV (S.L.), MBV (S.L.) (CSR&TI, Berhampore), and AP<sub>1</sub> (SLA) and AP<sub>1</sub> (SLB) (CSR&TI, Mysore). At the beginning these breeds had low viability, but the same has been overcome by subsequent selection at later generation (Table 8).

The sex-limited breeds are yet to become popular with the farmers.

### 3. Concurrent improvement of bivoltine breeds for utilization in cross breed.

As already stated, both multivoltine and bivoltine breeds are to be simultaneously improved to increase the silk yield in the country. In 1981, CSRTI, Mysore started a few breeding programme for bivoltines utilizing the breeds already developed by the Institute earlier. In fact with two decades of continuous endeavour this Institute is now having a good number of bivoltine breeds with different specific characters. The objectives of new breeding plans were:

- a) high temperature tolerant bivoltine races,
- b) high cocoon and shell weight,
- c) shorter larval period with high silk content,
- d) high resistance to disease infection (pupation ratio above 95%).

Under various research plans 6 Chinese and 6 Japanese type breeds were evolved in 1983. Out of which two Chinese type (oval cocoons) breeds viz: CA<sub>2</sub>, CC<sub>1</sub> and two Japanese type (dumbbell cocoons) JC<sub>1</sub>, JA<sub>2</sub>, JB<sub>2</sub> (Fig. 2) were found as very good combiner with the existing races (NB<sub>7</sub> and NB<sub>18</sub>) (Fig. 3). The rearing performances of the pure races as also the hybrids are presented in Tables 9, 10 and 11. It may be seen from there when combined the survival percentage exceeds 95% in all the seasons and the average cocoon yield/10,000 larvae is above 20 kg with a shell % of 22 to 23. As may be seen from the reeling data of these races of hybrids presented in Table 11 that reelability % is very high in new hybrids compared that in existing hybrids (NB<sub>7</sub> x NB<sub>18</sub>), consequently the renditta in the new hybrids (JC<sub>1</sub> x KA & JC<sub>1</sub> x NB<sub>7</sub>) has registered only 5.03 as against 6.63 in NB<sub>7</sub> x NB<sub>18</sub>. It is expected that with the release of these high yielding bivoltines, multi-bivoltine yield in the country will be further improved. The present breeds are under field trial.

## PERSPECTIVE BREEDING PLANS

### 1. Collection and maintenance of silkworm germplasm.

A separate Institute has to be established for maintaining the valuable commercial races/breeds as well as different genetical strains. The races/strains required for various breeding programme may be made to collect the races reared in South Asian countries whose climatic conditions simulate the conditions of many Indian states. An international germ plasm bank if established may cater to the need of further development of sericulture industry in Asian belt.

### 2. More Institutions for breeding.

At present silkworm breeding researches are chiefly confined in two major Institutions of Central Silk Board at Berhampore and Mysore, though Regional Sericultural Research Stations have also started limited breeding work. But the number of institutions is very limited compared to our requirement for breeds suited to variable agro-eco-climatic conditions of India. The Universities who have already taken up the sericulture course, and other private organizations should be encouraged to take up bivoltine and multivoltine breeding programme.

### 3. National race evaluation committee.

To utilize the existing races on national basis and to test and authorise the hybrids for commercial exploitation an expert body viz: Race Evaluation Committee at national level should be constituted. The committee will coordinate with breeding centres, and organize testing of new breeds in different regions of India and recommend the breeds for multiplication.

### 4. Special training programme for silkworm breeders.

Training programme for young scientists working in the branch of silkworm breeding could be developed under the following three categories:

- 1) developing in house training facilities;
- 2) specialized overseas training in silkworm breeding and genetics;
- 3) training of silkworm breeders in related animal breeding procedures.

### 5. Population genetics study.

At present in all breeding programme, artificial synthesis technique is followed by exploiting the variability in the existing races or breeds. Shortly time will reach when it may be difficult to synthesize more and more high yielding breeds. Population genetics approach would, therefore, be useful to solve this problem by resorting to reciprocal recurrent selections or modified recurrent reciprocal selections. Similarly non-additive genetic variations may also be exploited.

### 6. Bio-chemical genetics.

No biochemical genetics approach was so far taken up to improve the qualitative and quantitative traits though Datta (unpublished) has confirmed the identification of hybrid band in the electrophoretic analysis of blood esterase isozyme pattern for the first time in India. However, Gamo (1983), Hirata (1969) and Machida (1982) have clearly indicated relation between genes controlling various isozymes and economic characters. Kuroda's (1979) work indicated that ketoglutaric acid in larval haemolymph of silkworm has a significant correlation with the quantitative characters such as cocoon and cocoon shell weight.

### 7. Genetic engineering

Genetic engineering technique is now considered to be useful for the improvement of characters of plants and animals. This technique is also applicable to the silkworm breeding and recombination of foreign genes encoding enzymes into silkworms and will improve the efficiencies in feeding of mulberry leaves and protein synthesis of silkworm larvae.

| NAME        | Cocoon colour   | Cocoons per kg. (No.) | Single cocoon weight (gm) | Filament length (mt.) | Shell % | Denier |
|-------------|-----------------|-----------------------|---------------------------|-----------------------|---------|--------|
| Pure Mysore | greenish yellow | 1210                  | 0.826                     | 411                   | 11-12   | 1.7    |
| Nistari     | golden yellow   | 1408                  | 0.710                     | 270                   | 11-12   | 1.5    |
| Chotapolu   | yellow/white    | 1452                  | 0.688                     | 256                   | 10-11   | 1.8    |
| Sarupat     | yellow/white    | 1716                  | 0.582                     | 247                   | -       | 1.6    |
| Moria       | greenish yellow | 1108                  | 0.902                     | 335                   | 14.0    | 2.3    |

(Source : 1-4 M. Nangvathy 1965; 5 CSRTI, Ann. Rept. 1980)

Table 1. Performance of Indian multivoltine silkworm races

| RACE              | Eggs<br>laying | Hatching<br>% | Larval<br>duration<br>Days : Hrs. | Yield/10,000 larvae |          | Cocoon<br>weight<br>(gms) | Shell<br>weight<br>(gms) | Shell<br>ratio<br>% | Sth age<br>larval<br>duration | Melting<br>% | Cocoon/<br>litre |
|-------------------|----------------|---------------|-----------------------------------|---------------------|----------|---------------------------|--------------------------|---------------------|-------------------------------|--------------|------------------|
|                   |                |               |                                   | No.                 | Wt.(Kg.) |                           |                          |                     |                               |              |                  |
| NB7 (oval)        | 506            | 95.7          | 23 : 22                           | 8730                | 15.529   | 1.779                     | 0.377                    | 21.2                | 6:12                          | 2.6          | 64               |
| NB18<br>(Peanut)  | 638            | 92.2          | 25 : 13                           | 8481                | 15.815   | 1.865                     | 0.395                    | 21.2                | 7:15                          | 2.7          | 74               |
| NB7xNB18          | -              | 96.7          | 24 : 01                           | 9264                | 19.120   | 2.064                     | 0.445                    | 21.6                | 7:01                          | 1.5          | 59               |
| KA (oval)         | 579            | 94.6          | 23 : 18                           | 8776                | 15.676   | 1.786                     | 0.350                    | 19.6                | 6:16                          | 4.2          | 60               |
| NB402<br>(Peanut) | 572            | 96.0          | 24 : 09                           | 9106                | 17.480   | 1.920                     | 0.399                    | 20.8                | 7:08                          | 3.0          | 60               |
| KAxNB402          | -              | 95.9          | 24 : 01                           | 9564                | 18.264   | 1.909                     | 0.406                    | 21.2                | 7:00                          | 0.2          | 60               |

Table 2. Rearing performance of races evolved by CSRTI  
(Average of 4 seasons, 1983)

| Sl. No. | Race            | Larval period (D.H.) | E.R.R. % | Cocoon yield/ 10,000 larvae (kg) | Cocoon weight (gm) | Shell weight (gm) | Shell ratio | Floss % | Filament length (mtr) | Reference                      |
|---------|-----------------|----------------------|----------|----------------------------------|--------------------|-------------------|-------------|---------|-----------------------|--------------------------------|
| 1.      | Nistid          | 24:13                | 95.7     | 9.41                             | 0.95               | 0.12              | 12.7        | -       | 313                   | AR.CSRTI, 1978                 |
| 2.      | A4e             | 25:23                | 88.0     | 10.78                            | 1.19               | 0.18              | 15.0        | 7.2     | 462                   | - do -                         |
| 3.      | MBD IV          | 24:00                | 80.1     | 7.06                             | 0.84               | 0.13              | 15.5        | -       | 527                   | AR.CSRS, Berhampore, 1969      |
| 4.      | DI4b            | 25:00                | 77.5     | 7.37                             | 0.96               | 0.14              | 14.3        | -       | 601                   | - do -                         |
| 5.      | Nistari         | 24:06                | 93.4     | 8.20                             | 0.86               | 0.11              | 13.0        | -       | 296                   | - do -                         |
| 6.      | Mysore Princes  | 24:20                | 95.6     | 12.16                            | 1.26               | 0.20              | 15.7        | 4.7     | 577                   | AR.CSRTI, 1978                 |
| 7.      | IEP 2           | -                    | 72.3     | -                                | 1.08               | 0.16              | 15.9        | 2.2     | 565                   | Narasimhanna & Gururajan, 1964 |
| 8.      | NS4             | 25:13                | 84.4     | 9.98                             | 1.16               | 0.20              | 17.1        | 6.4     | 401                   | AR.CSRTI, 1978                 |
| 9.      | Hosa Mysore     | 26:18                | 89.2     | 13.29                            | 1.45               | 0.25              | 17.3        | 9.1     | 540                   | - do -                         |
| 10.     | Tamilnadu white | 25:12                | 89.6     | 8.85                             | 1.00               | 0.14              | 14.0        | -       | 355                   | - do -                         |
| 11.     | Pure Mysore     | 29:20                | 90.9     | 8.44                             | 0.91               | 0.13              | 14.2        | 18.4    | 285                   | - do -                         |

(Data collected from CSRTI Berhampore & Mysore)

Table 3. Performance evolved multivoltine breeds

Performance of CB2 & CB5 evolved at CSRT&I, Berhampore  
(average of 6 seasons of 1979)

| Race    | Total No.<br>of eggs | Hatching<br>% | Weight of<br>10 larvae | Yield/10,000<br>larvae |         | Single        |              | S.R. % | Filament<br>length |
|---------|----------------------|---------------|------------------------|------------------------|---------|---------------|--------------|--------|--------------------|
|         |                      |               |                        | No.                    | Wt.(kg) | Cocoon<br>wt. | Shell<br>wt. |        |                    |
| CB2     | 479                  | 95.0          | 25.0                   | 8475                   | 9.266   | 1.05          | .15          | 14.2   | 560                |
| CB5     | 455                  | 98.2          | 25.6                   | 8511                   | 9.925   | 1.10          | .18          | 16.4   | 630                |
| Nistari | 399                  | 95.6          | 18.2                   | 7520                   | 5.895   | 0.83          | .09          | 10.8   | 429                |

Field performance of commercial crop done through E.D.C. West Dinajpur & Malda  
(1979)

| Race      | Hatching<br>% | Larval<br>period<br>(days) | Wt. of mature<br>larvae<br>(gm) | Yield/100<br>layings |
|-----------|---------------|----------------------------|---------------------------------|----------------------|
| CB2 x CB5 | 96.76         | 22                         | 29                              | 22.070               |
| CB5 x CB2 | 94.29         | 22                         | 27                              | 29.650               |

Table 4.

| Season/<br>Race  | Fecundity | Hatching<br>% | Larval<br>duration<br>O:H | Pupation<br>wt.<br>10,000 larvae | Yield<br>wt. | Cocoon<br>wt. | Shell<br>wt. | Shell<br>ratio | Floss<br>(%) | Hibernation<br>(%) |
|------------------|-----------|---------------|---------------------------|----------------------------------|--------------|---------------|--------------|----------------|--------------|--------------------|
| Oec. Jan. '84    |           |               |                           |                                  |              |               |              |                |              |                    |
| PMS <sub>2</sub> | 478       | 93.2          | 23:20                     | 9866                             | 11.970       | 1.213         | 0.196        | 16.2           | 13.7         | nil                |
| PM (control)     | 392       | 94.9          | 30:00                     | 9626                             | 8.600        | 0.892         | 0.126        | 14.1           | 22           | "                  |
| PM X             | 459       | 83.0          | 25:20                     | 8950                             | 10.937       | 1.221         | 0.184        | 15.0           | 16.5         | "                  |

Table 5. Pure Mysore with shorter larval period evolved through radiation and selection.

| Sl. No. | Race        | Fecundity | Hatching % | Larval duration | Pupation ratio/ 10,000 larvae (No.) | Yield/ weight (kg.) | Cocoon weight (gm) | Shell weight (gm) | Shell ratio (%) | Floss % |
|---------|-------------|-----------|------------|-----------------|-------------------------------------|---------------------|--------------------|-------------------|-----------------|---------|
| 1.      | MY1         | 562.50    | 91.67      | 23.7            | 9137.33                             | 11.628              | 1.242              | 0.169             | 13.2            | 9.766   |
| 2.      | MY2         | 526.67    | 92.73      | 23.8            | 8915.66                             | 12.670              | 1.392              | 0.207             | 14.8            | 11.033  |
| 3.      | MW1         | 529.67    | 93.46      | 22.4            | 8936.66                             | 13.542              | 1.485              | 0.251             | 15.8            | 7.50    |
| 4.      | MW2         | 542.33    | 89.9       | 22.7            | 8362.00                             | 13.241              | 1.569              | 0.261             | 16.8            | 7.73    |
| 5.      | Hosa Mysore | 536.00    | 92.46      | 24.1            | 7981.66                             | 12.225              | 1.555              | 0.238             | 15.4            | 12.20   |
| 6.      | Pure Mysore | 357.66    | 91.53      | 28.9            | 8610                                | 8.161               | 0.956              | 0.120             | 12.7            | 17.53   |

Table 6. Performance of new multivoltine breeds evolved at CSR&TI  
using different indigenous races and multivoltine breeds  
Average of three seasons (1983-84)

| Sl. No. | Race     | Eggs/ laying | Larvae brushed | Hatching % | Larval duration D:H | Yield/10,000 larvae |        | Cocoon weight (gm) | Shell weight (gm) | Shell ratio (%) | 5th age larval duration D:H | Floss (%) |
|---------|----------|--------------|----------------|------------|---------------------|---------------------|--------|--------------------|-------------------|-----------------|-----------------------------|-----------|
|         |          |              |                |            |                     | No.                 | Wt.    |                    |                   |                 |                             |           |
| 1.      | MY1xN87  | 550          | 521            | 94.7       | 23:20               | 8549                | 15.352 | 1.827              | 0.315             | 17.2            | 8:00                        | 7.8       |
| 2.      | MY1xN818 | 574          | 541            | 94.2       | 25:06               | 8961                | 16.904 | 1.887              | 0.317             | 16.8            | 8:12                        | 6.9       |
| 3.      | MY2xN87  | 527          | 492            | 93.2       | 23:12               | 8442                | 16.726 | 1.982              | 0.325             | 16.3            | 7:07                        | 7.7       |
| 4.      | MY2xN818 | 514          | 434            | 84.4       | 24:00               | 8679                | 17.100 | 1.969              | 0.346             | 17.3            | 8:04                        | 6.5       |
| 5.      | MW1xN87  | 644          | 548            | 85.0       | 23:20               | 8892                | 17.715 | 1.999              | 0.349             | 17.4            | 7:07                        | 5.3       |
| 6.      | MW1xN818 | 599          | 530            | 88.5       | 24:20               | 8186                | 14.583 | 1.780              | 0.296             | 16.6            | 7:16                        | 5.7       |
| 7.      | MW2xN87  | 472          | 450            | 95.3       | 24:12               | 8793                | 14.137 | 1.676              | 0.300             | 17.8            | 7:19                        | 5.7       |
| 8.      | MW2xN818 | 564          | 551            | 97.5       | 23:12               | 7692                | 12.113 | 1.574              | 0.244             | 15.4            | 6:21                        | 8.4       |
| 9.      | HMxN87   | 516          | 474            | 91.7       | 23:12               | 7745                | 14.387 | 1.986              | 0.294             | 15.7            | 7:01                        | 5.8       |
| 10.     | HMxN818  | 609          | 538            | 87.3       | 24:20               | 8609                | 17.095 | 1.986              | 0.339             | 17.0            | 8:00                        | 5.8       |
| 11.     | PMxN87   | 385          | 373            | 96.9       | 24:20               | 8990                | 15.960 | 1.441              | 0.274             | 19.0            | 7:22                        | 10.6      |
| 12.     | PMxN818  | 277          | 248            | 89.4       | 25:12               | 9733                | 17.110 | 1.759              | 0.286             | 16.2            | 6:17                        | 9.7       |

Table 7. Rearing performance of new multivoltine hybrids  
Season : Oct/Nov. 1983

| Season               | Fecundity           | Hatching<br>% | Larval<br>duration<br>D:H | Sex | Yield/10,000<br>larvae |        | Single<br>cocoon<br>wt. (gm) | Single<br>shell<br>wt. (gm) | S.R.<br>% | Floss<br>(%) |
|----------------------|---------------------|---------------|---------------------------|-----|------------------------|--------|------------------------------|-----------------------------|-----------|--------------|
|                      |                     |               |                           |     | No.                    | Wt.    |                              |                             |           |              |
| <u>July, Aug. 83</u> |                     |               |                           |     |                        |        |                              |                             |           |              |
| AP1(SLA)             | 462                 | 90.4          | 22:20                     | M   | 9525                   | 11.875 | 1.380                        | 0.236                       | 16.6      | 11.8         |
|                      |                     |               |                           | F   | 9550                   | 16.500 | 1.700                        | 0.242                       | 14.2      | 12.1         |
| AP1(SLB)             | 495                 | 89.7          | 23:20                     | M   | 8225                   | 11.400 | 1.318                        | 0.222                       | 16.8      | 11.4         |
|                      |                     |               |                           | F   | 7250                   | 11.025 | 1.624                        | 0.232                       | 14.2      | 11.0         |
| <u>Oct. Nov. 83</u>  |                     |               |                           |     |                        |        |                              |                             |           |              |
| AP1(SLA)             | composit<br>layings | 87.5          | 24:08                     | M   | 8275                   | 10.850 | 1.166                        | 0.227                       | 19.3      | 9.2          |
|                      |                     |               |                           | F   | 8225                   | 11.750 | 1.456                        | 0.248                       | 16.9      | 10.0         |
| AP1(SLB)             | "                   | 73.7          | 24:21                     | M   | 7225                   | 9.250  | 1.172                        | 0.204                       | 17.3      | 12.0         |
|                      |                     |               |                           | F   | 8650                   | 12.750 | 1.356                        | 0.204                       | 14.9      | 11.0         |
| <u>Dec. Jan. 84</u>  |                     |               |                           |     |                        |        |                              |                             |           |              |
| AP1(SLA)             | "                   | 88.0          | 24:03                     | M   | 9760                   | 15.106 | 1.706                        | 0.286                       | 17.24     | 9.8          |
|                      |                     |               |                           | F   | 8530                   | 16.600 | 1.772                        | 0.306                       | 16.76     | 9.4          |
| AP1(SLB)             | "                   | 73.4          | 24:15                     | M   | 8750                   | 12.575 | 1.442                        | 0.270                       | 18.75     | 9.6          |
|                      |                     |               |                           | F   | 8050                   | 13.750 | 1.713                        | 0.284                       | 16.57     | 8.8          |
| <hr/>                |                     |               |                           |     |                        |        |                              |                             |           |              |
| Av. AP1(SLA)         |                     |               | 23:18                     | M   | 9186                   | 12.610 | 1.417                        | 0.247                       | 17.7      | 10.2         |
|                      |                     |               |                           | F   | 8768                   | 14.950 | 1.642                        | 0.265                       | 15.9      | 10.5         |
| Av. AP1(SLB)         |                     |               | 24:10                     | M   | 8066                   | 11.075 | 1.310                        | 0.232                       | 17.61     | 11.0         |
|                      |                     |               |                           | F   | 7983                   | 12.508 | 1.564                        | 0.240                       | 15.22     | 10.26        |

Table 8. Performance of sex-limited multivoltine strains - AP1(SLA) and AP1(SLB)

| Race                               | Eggs<br>layings      | Hatching<br>% | Larval<br>duration<br>Days:Hrs. | Yield/1000<br>larvae brushed |             | Cocoon wt.<br>(gms) | Shell wt.<br>(gms) | Shell ratio<br>% | 5th age<br>larval<br>duration | Melting | Cocoon/<br>litre |
|------------------------------------|----------------------|---------------|---------------------------------|------------------------------|-------------|---------------------|--------------------|------------------|-------------------------------|---------|------------------|
|                                    |                      |               |                                 | Pupation<br>No.              | Wt.<br>(kg) |                     |                    |                  |                               |         |                  |
| CA <sub>2</sub> (Oval)             | 617                  | 94.5          | 24:00                           | 9197                         | 17.798      | 1.935               | 0.424              | 21.9             | 7:06                          | 3.3     | 65               |
| CC <sub>1</sub> (Oval)             | 640                  | 96.5          | 23:23                           | 9244                         | 17.971      | 1.938               | 0.413              | 21.3             | 7:04                          | 3.2     | 59               |
| CA <sub>2</sub> x NB <sub>18</sub> | Composite<br>layings | 96.2          | 24:02                           | 9644                         | 21.090      | 2.182               | 0.477              | 21.9             | 7:06                          | 0.7     | 62               |
| CC <sub>1</sub> x NB <sub>18</sub> | do                   | 95.8          | 24:02                           | 9742                         | 21.380      | 2.194               | 0.460              | 21.0             | 7:01                          | 1.3     | 59               |
| JB <sub>2</sub> (Peanut)           | 602                  | 87.3          | 25:20                           | 8233                         | 15.106      | 1.835               | 0.418              | 22.8             | 8:02                          | 1.9     | 85               |
| JC <sub>1</sub> (Peanut)           | 640                  | 93.4          | 25:08                           | 8239                         | 15.346      | 1.863               | 0.424              | 22.8             | 7:22                          | 3.9     | 76               |

Table 9. Rearing performance of new breeds evolved by CSRTI (1983)  
(Average of 4 seasons)

| Race                              | No. of OfIs       | Hatching % | Larval duration Days:Hrs. | Yield/10,000 larvae brushed |          | Cocoon wt. (gms) | Shell wt. (gms) | Shell ratio % | 5 th age larval duration | Melting % | Cocoon/ litre |
|-----------------------------------|-------------------|------------|---------------------------|-----------------------------|----------|------------------|-----------------|---------------|--------------------------|-----------|---------------|
|                                   |                   |            |                           | Pupation No.                | Wt. (Kg) |                  |                 |               |                          |           |               |
| Oct./Nov. 1983                    |                   |            |                           |                             |          |                  |                 |               |                          |           |               |
| JA <sub>2</sub> X KA              | Composite layings | 95.3       | 23:23                     | 9555                        | 20.321   | 2.127            | 0.456           | 21.2          | 6:23                     | 0.8       | 56            |
| JA <sub>2</sub> X NB <sub>7</sub> | "                 | 95.3       | 23:23                     | 9422                        | 20.477   | 2.173            | 0.474           | 21.8          | 6:23                     | 2.8       | 57            |
| JC <sub>1</sub> X KA              | "                 | 82.6       | 24:08                     | 9622                        | 20.655   | 2.146            | 0.480           | 22.4          | 7:08                     | 0.3       | 54            |
| JC <sub>1</sub> X NB <sub>7</sub> | "                 | 77.5       | 24:15                     | 9544                        | 19.722   | 2.066            | 0.472           | 22.8          | 7:15                     | 1.4       | 58            |
| Dec./Janv.1983-84                 |                   |            |                           |                             |          |                  |                 |               |                          |           |               |
| CA <sub>2</sub> X JB <sub>2</sub> | Composite layings | 94.8       | 24:20                     | 9250                        | 19.616   | 2.121            | 0.485           | 22.9          | 7:06                     | 2.6       | 59            |
| CA <sub>2</sub> X JC <sub>1</sub> | "                 | 95.8       | 24:20                     | 9816                        | 21.767   | 2.217            | 0.512           | 23.1          | 7:20                     | 0.5       | 58            |
| CC <sub>1</sub> X JB <sub>2</sub> | "                 | 97.7       | 24:20                     | 9416                        | 20.500   | 2.176            | 0.499           | 22.9          | 7:08                     | 1.3       | 60            |
| CC <sub>1</sub> X JC <sub>1</sub> | "                 | 96.3       | 24:20                     | 9183                        | 21.200   | 2.314            | 0.507           | 21.9          | 7:08                     | 1.0       | 54            |

Table 10. Rearing of new hybrids (new x new ; new x existing)

| Race                               | Shell ratio<br>% | Average filament<br>length of cocoon<br>(mtr) | Average denier<br>of the filament | Renditta | Reelability<br>% | Neatness |
|------------------------------------|------------------|-----------------------------------------------|-----------------------------------|----------|------------------|----------|
| CA <sub>2</sub> (Oval)             | 22.3             | 1157                                          | 2.62                              | 6.20     | 87.7             | 87.5     |
| CC <sub>1</sub> (Oval)             | 22.0             | 1050                                          | 2.93                              | 6.30     | 87.5             | 92.0     |
| CA <sub>2</sub> x NB <sub>18</sub> | 22.0             | 1150                                          | 2.87                              | 6.30     | 82.0             | 91.0     |
| CC <sub>1</sub> x NB <sub>18</sub> | 21.5             | 1120                                          | 2.75                              | 6.50     | 81.0             | 91.5     |
| JB <sub>2</sub> (Peanut)           | 23.4             | 1008                                          | 2.76                              | 6.24     | 75.3             | 88.0     |
| JC <sub>1</sub> (Peanut)           | 24.5             | 1185                                          | 3.34                              | 5.41     | 89.3             | 91.5     |
| JB <sub>2</sub> x KA               | 21.4             | 1215                                          | 3.24                              | 5.80     | 90.6             | 90.5     |
| JB <sub>2</sub> x NB <sub>7</sub>  | 22.5             | 1185                                          | 2.88                              | 5.53     | 85.4             | 92.5     |
| JC <sub>1</sub> x KA               | 22.4             | 1267                                          | 3.12                              | 5.02     | 93.7             | 92.5     |
| JC <sub>1</sub> x NB <sub>7</sub>  | 22.8             | 1311                                          | 2.92                              | 5.03     | 93.1             | 93.0     |
| NB <sub>7</sub> x NB <sub>18</sub> | 22.7             | 890                                           | 2.78                              | 6.63     | 77.7             | 93.0     |

Table 11. Reeling data of new bivoltine breeds vis-à-vis hybrids (new and existing)

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## ***PROGRESS THROUGH BREEDING***

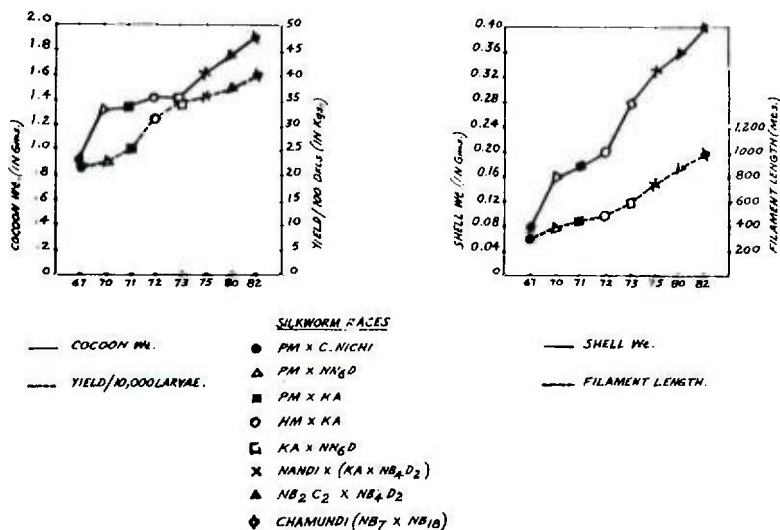


Figure 1.

Improvement of silkworm quantitative traits during the past 15 years.

Note the steady improvement of yield/100 dfls and cocoon shell weight since 1972.

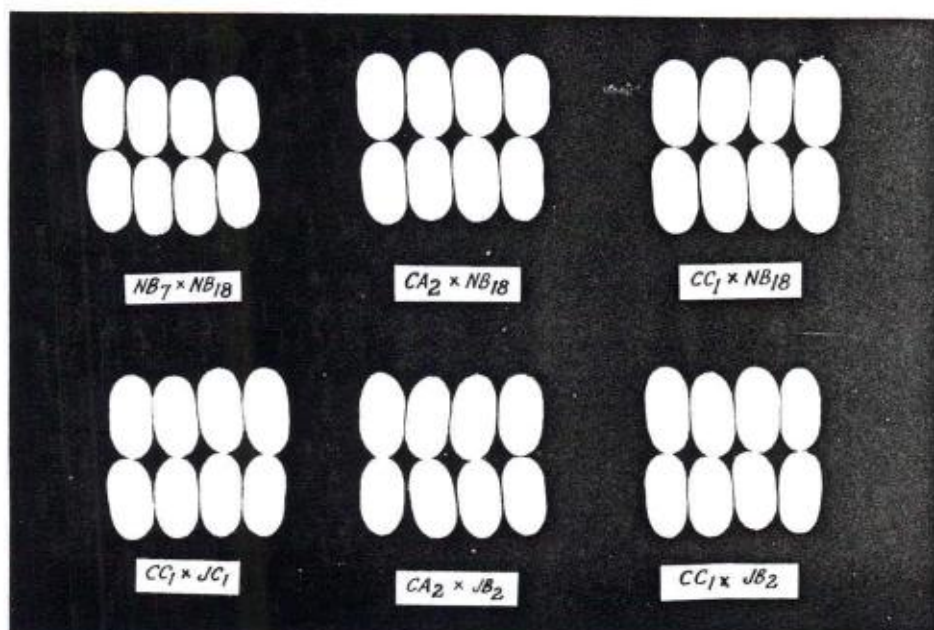
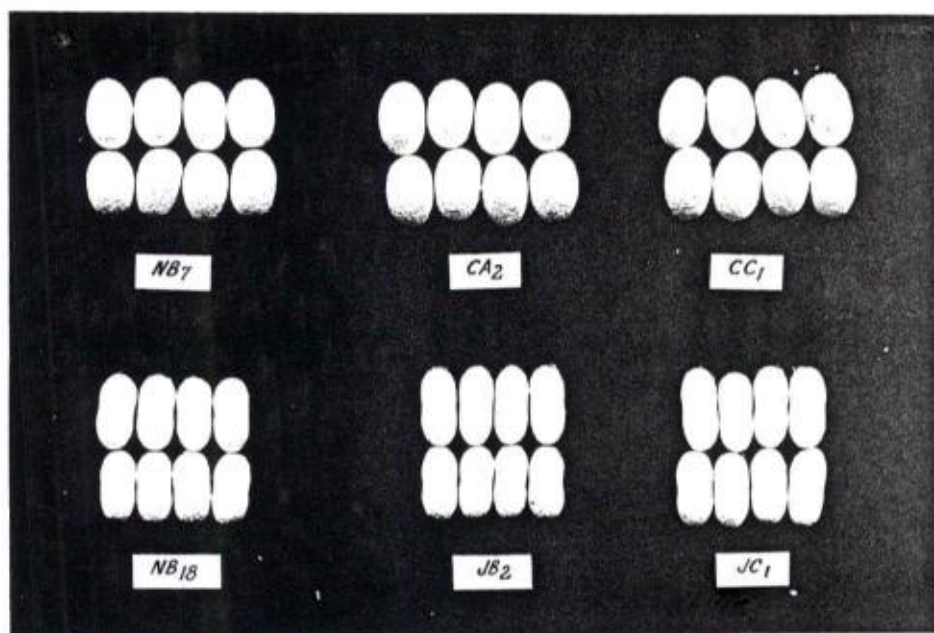
PM = Pure Mysore (multivoltine)  
 HM = Hosa Mysore (multivoltine)  
 KA = Kalimpong A (bivoltine)

Figure 2.

Cocoon samples of newly evolved breeds, CA<sub>2</sub> & CC<sub>1</sub> (Chinese type)  
and JB<sub>2</sub> & JC<sub>1</sub> (Japanese type) vis-à-vis existing breeds NB<sub>7</sub> and NB<sub>18</sub>

Figure 3.

Cocoon samples of hybrids (existing x new ; existing x existing)



POPULARIZATION OF THE COOPERATIVE REARING FOR YOUNG  
SILKWORM WITH ARTIFICIAL DIETS AND PROSPECTIVE PROBLEMS

VULGARISATION DE LA COOPERATIVE D'ELEVAGE POUR LES JEUNES VERS A SOIE  
NOURRIS SUR ALIMENTS ARTIFICIELS ET PROBLEMES QUI PEUVENT  
SE POSER DANS LE FUTUR

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*The process of popularization of the cooperative rearing for young silkworm with artificial diets in Japan was briefly described from the extension side.*

*Thereafter, the following problems to be solved in the near future were pointed out : (1) further improvement of the components in diets, especially for the 3rd instar, including decrease of the amount of mulberry leaf powder in them, (2) establishment of the effective techniques for long term storage and quality maintenance of the diets, (3) countermeasures in maintenance of the hygienic environment in rearing facilities, and (4) breeding of the silkworm varieties more suitable for artificial diets.*

*Nous avons brièvement décrit le processus de vulgarisation et de développement de la coopérative d'élevage pour les jeunes vers à soie nourris sur aliments artificiels au Japon. Nous avons ensuite abordé les problèmes qu'il faudra résoudre dans un proche avenir : (1) amélioration de l'alimentation, particulièrement pour le 3ème âge, y compris diminution de la quantité de poudre de feuilles de mûrier dans la composition du régime alimentaire; (2) mise au point de techniques efficaces de longue conservation des aliments; (3) maintien des installations d'élevage dans de bonnes conditions d'hygiène; (4) élevage de vers à soie mieux adapté à une alimentation artificielle.*

## 1. Extension situation of the younger silkworm rearing on artificial diets.

a) Researches on the artificial diets for the silkworm has commenced for the purpose of the development of a substitute in place of mulberry leaves, or the materials for researches on the nutrition and the physiology of the silkworm.

An entire rearing of the silkworm on artificial diets including dried mulberry leaf powder has been achieved to let the silkworm make cocoons for the first time at the Ministry of Agriculture and Forestry's Sericultural Experiment Station in 1960.

Since that time, in 1970s the research has widely and systematically been conducted in establishment of the rearing method, improvement of components of the diets etc. With the younger silkworms (see Table 1) composed mainly of dried mulberry leaf powder, defatted soybean meal, cellulose powder, the standard rearing system for the younger silkworm on artificial diets has been established.

Table 1. Standard components of the artificial diets for the younger silkworm.

| Substance                                | Dry diet (%)   |
|------------------------------------------|----------------|
| Dried mulberry leaf powder               | 25             |
| Corn starch                              | 7.5            |
| Sucrose                                  | 8              |
| Defatted soybean meal                    | 36             |
| Refined soybean oil                      | 1.5            |
| Soybean sterol                           | 0.2            |
| Salt mixture                             | 3              |
| Cellulose powder                         | 15             |
| Agar                                     | 7.5            |
| Ascorbic acid                            | 1              |
| Citric acid                              | 4              |
| Total                                    | 108.7          |
| Vitamin B mixture                        | added          |
| Antiseptic (sorbic acid, propionic acid) | added          |
| Antibiotic                               | added          |
| Water                                    | 2.57 ml/g diet |

b) Based on results of the research, the study on introduction of the silkworm rearing technics on artificial diets as the practical one into sericultural farmers has been conducted.

Considering with the expense for rearing facilities, labour cost and other economical factors and technical factors looking for the large scale silkworm rearing,

etc., introduction of this technics into the younger instars of silkworms has been concluded as desirable for rationalization in the farm management as well as the stabilized good crop in sericulture.

c) In this respect, the rearing technics on artificial diets have been introduced into the younger silkworm cooperative rearing house as managed by sericultural farmers cooperatively. For the smooth development of this technics, achievement of the stabilized silkworm rearing technics was important. Since 1974, it has come into a full scale extension period as solving the technical problem as well as arranging the full equipment of facilities for the silkworm rearing environment.

d) Year after year, such younger silkworm rearing houses have increased steadily as having condition to carry out the silkworm rearing on artificial diets safely like cleaning up the silkworm rearing environment, controlling the temperature and humidity as required, etc.

In 1982, 200 younger silkworm cooperative rearing houses on artificial diets have been constructed. Due to such increase of the silkworm rearing houses, ratio of the silkworm eggs used for the younger silkworm rearing on artificial diets to the total silkworm eggs used for the silkworm rearing increased from 0.8% in 1977 to 22.5% in 1983, or 406,000 boxes (20,000 eggs each) in quantity (see Table 2).

Table 2. Extension situation of the younger silkworm rearing\* on artificial diets.

| Total silkworm eggs<br>used for rearing |                 | Of which for rearings of younger silkworms on<br>artificial diets |                    |
|-----------------------------------------|-----------------|-------------------------------------------------------------------|--------------------|
|                                         |                 | Silkworm eggs used                                                | Ratio of extension |
| (1)                                     |                 | (2)                                                               | (2)/(1)            |
| 1977                                    | 2,516,300 boxes | 21,034 boxes                                                      | 0.8 %              |
| 1980                                    | 1,804,100 boxes | 405,850 boxes                                                     | 22.5 %             |

\* for reelable cocoons

Extension of the rearing on artificial diets of younger parent silkworms has been subsidized by the Government since 1977 for the purpose of producing excellent quality cocoons, reaching 24.1% to the total rearing boxes of parent silkworm eggs in 1983.

## 2. Problems in the future.

a) The younger silkworm rearing on artificial diets can reduce labour cost because of decrease of number of feedings, etc, while cost per unit rearing amount becomes a little higher than the rearing on mulberry leaves as not only feed cost is higher than the mulberry leaf but also more cost is required in keeping the environmental facilities to clean up.

Reduction of each factor raising cost is required respectively. In this respect, keeping the optimum amount of feeds and developing of the artificial diet having highly feeding efficiency in lower cost are required, while guidance to have more efficient designing of the younger silkworm cooperative house on artificial diets are being conducted.

b) Majority of the current younger silkworm cooperative rearing house are available for the 1st to 2nd instar silkworms, but the cooperative rearing period is desired to extend to the 3rd instar in view of much more stabilization of cocoon crops or better distribution of labour required for the multiple rearing.

Along this line, researches on improvement of more economical rearing facilities and technics looking for the rearing of the 1st to 3rd instars on artificial diets, and improvement of composition of artificial diets are being promoted.

c) A countermeasure is required not to have competition in getting mulberry leaves between farmers who rear the silkworm on the mulberry leaf and those who depend on artificial diets containing the dried mulberry leaf powder as much as 20 to 30%.

d) In promoting the younger silkworm rearing on artificial diets, securing artificial diets as well as reducing the production cost are required.

Current effective storing period of the artificial diets is thought as around 2 months in a cold and dark storing condition. Preparation of artificial diets is concentrated within a limited period before the silkworm rearing as well as the quantity prepared is limited, resulting barrier of reduction of cost which is brought by a mass production. In this respect, a research is desired for developing a long-term storing technics of artificial diets.

e) For controlling the artificial diets from spoiling and keeping the silkworms from disease germs, it is important to keep the silkworm rearing environment clean. For this, development of the fully equipped facilities to secure a clean environment as cheap as possible is desirable.

f) For stabilized extension of the silkworm rearing on artificial diets in the future, excellent quality will always be required, while the guidance to organize a system controlling not to distribute and use inferior quality artificial diets is also desired. In this connection, currently a checking system in quality through the rearing test at the artificial diets manufacturing plants as well as the silkworm cooperative rearing houses is adopted.

g) On the other hand, in order to let artificial diets bring in full play much more as effects of feeds, breeding the most suitable silkworm varieties for the rearing on artificial diets is required, while improving characters of the silkworm variety such as feeding habit.

In this connection, the Government changed its policy to separate designation of the silkworm varieties for the younger silkworm rearing on artificial diets from those for rearing on the mulberry leaf since 1981. As of March 1984, designated silkworm varieties for the younger silkworm rearing on artificial diets amounted to 20 varieties.

**SILKWORM SEED ORGANIZATION VITAL FOR SOUND SERICULTURE  
IN TROPICAL COUNTRIES**

**L'ORGANISATION DU GRAINAGE DU VER A SOIE EST VITAL POUR UNE  
SERICULTURE DANS LES PAYS TROPICAUX**

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Silkworm seed is the sheet anchor of sericulture industry. Disease free silkworm seed is the base for a sound sericulture programme. Pebrine disease is both contaminative and 'hereditary'. Of all the diseases it causes major threat to the industry. Quality silkworm seed governs productivity and production of silk. It is also responsible for the quality of silk produced. Multivoltine silkworm breeds produce inferior silk while bivoltine produce superior silk. Recently technologies to rear bivoltines in tropical conditions have been introduced. Hybrid vigour has been exploited for better yields and quality of silk in both temperate and tropical conditions. Hybrid silkworms yield more silk as compared to pure races and their survival rate is better. Hence production of quality hybrid silkworm seed plays a vital role in the future of silk industry.

Two aspects of the silkworm seed production govern the production as well as the productivity of silk. They are:

1. Supply of disease free layings;
2. Supply of vigorous silkworm eggs which yield quality cocoons and rich silk recovery.

**Supply of disease free layings**

Organized seed production, free from disease is vital for any systematic silk production programmes, whether it is multivoltine or bivoltine areas. Lack of disease free silkworm seed supply had lead to devastation of sericulture industry in France.

Louis Pasteur laid emphasis on female moth examination to detect pebrine disease and laid foundation for production of disease free silkworm eggs. Pebrine disease causes more havoc to the sericulture than any other diseases, this is because this disease is both contaminative and hereditary while other diseases are only contaminative.

Japanese scientists have identified different species of pebrine in *Bombyx mori*. It is also reported that wild insects act as carriers of these pathogens. A clear study of these pebrine pathogens is essential. Systematic study of these in other countries have to be taken up. Free flow of literature on the behaviour and response of pathogens is essential in this direction. Studies on the behaviour of these pathogens in different climatic conditions is also necessary.

In sericulturally advanced countries like China, Japan, South Korea and U.S.S.R., a systematic production of silkworm eggs is streamlined through various legislative measures. In U.S.S.R. and China the Government takes the responsibility of supply of disease free silkworm eggs. In Japan and South Korea, the Government has legislative measures to control quality of seed by the private grainages.

Every effort is made in the developed countries to eradicate pebrine. Scientific methods are evolved in isolating diseased eggs by meticulous examination of mother moth. In U.S.S.R. this is ensured either by examination of individual moth or in groups of 2 and 5 moths. This is possible because of long time gap between seed preparation and its utility of univoltine breeds. In Japan and South Korea moth examination is streamlined by a system of sample testing. This is possible because of sericulture hygiene practised by seed cocoon growers.

In India, legislative measures controlling the quality of silkworm seed are in force in advanced sericulture states of the country. Silkworm seed is produced both by Government and Private grainages. 60% of the requirement of silkworm seed is produced by private agencies, while certain measures can be enforced in governmental organizations, it is difficult to control the private organizations.

Production of disease free silkworm eggs is lacking in some of the developing countries which has naturally led to the prevalence of pebrine disease causing extensive damage to the industry. It is necessary that stringent measures to produce disease free layings are strictly followed through legislation and quality control in all the developing countries.

Possibilities of eradicating pebrine disease on worldwide basis like eradication of small pox in human being (in the entire world) has to be thought of. It is an accepted fact that pebrine disease poses a major threat to the sericulture industry in the universe.

#### Production and timely supply of silkworm eggs

Rearing of silkworms is a time bound programme. In temperate conditions like Japan, U.S.S.R., South Korea, silkworm rearing synchronize with the sprouting of mulberry leaves in spring. In tropical conditions like India, though there are four season bound programmes of silkworm rearing in West Bengal state, in Karnataka state it is a continuous programme without any seasonal limitations. Salubrious climate in Karnataka permits rearing of silkworms throughout the year. In developing tropical countries also rearing of silkworms is controlled by climatic factors. Timely supply of silkworm seed assumes importance immaterial of seasonal or continuous silkworm rearing practices. Failure to supply adequate quantity of quality silkworm eggs to the farmer results in wastage of leaf in a season bound programme while in unconditional rearing it affects that particular cocoon crop and the succeeding crop due to improper growth and maturity of mulberry leaf.

Production of disease free silkworm eggs in tropical conditions poses many problems. Imposing sericulture hygiene at seed cocoon rearings, systematizing moth examination to detect pebrine and propagating sericulture hygiene with cocoon growers are necessary. Individual moth examination in multivoltine to certify the seed naturally becomes laborious in view of shortage of time between seed production and its utilization. Suitable methodologies are necessary for effective examination of disease. Japanese method of sample testing of moths can only be practised if seed cocoon growers follow sericulture hygiene meticulously.

One of the major difficulties faced by the tropical countries is the sudden demand for silkworm eggs during the outbreak of monsoon. Mulberry being grown mostly under rainfed conditions sprouts fast after rains, thereby creating a sudden demand for silkworm eggs. Due to shortage of seed, farmers prepare seed themselves even without conducting microscopic examination of moths which lead to failure of crops and spread of diseases. This situation can be overcome if the bivoltine silkworm eggs are used in tropical conditions. Bivoltine silkworm eggs can be stored by following different hibernation schedules for release during demand period. However, farmers in tropical conditions are not fully convinced of the success of bivoltine silkworm rearing. They feel that the cocoon yield in bivoltine is lower than in multivoltine hybrids as they are not well acclimatized to the tropical conditions. Hybrids of bivoltine female x multivoltine male where hibernation is imparted by the mother moth and having the same survival capacity as their reciprocal can be tried. Such eggs can be stored long by following hibernation schedules. This may help to overcome the sudden demand for silkworm eggs during monsoon season in tropical countries.

#### Supply of silkworms eggs with high cocoon productivity and rich silk recovery

##### Exploitation of hybrid vigour:

Silkworm is one of the many insects where heterosis has been exploited commercially to the maximum. Advanced countries have taken to production of foundation hybrids for seed production and poly-hybrids are determined and released to field by research institutes. In many of the developing countries multivoltine pure races are still used. Cocoon yield and silk recovery are poor. It is established that hybrids of multivoltine x bivoltine yield comparatively superior quality cocoons with less loss, higher silk content and better survival rate than the multivoltine pure races. This situation has to be fully exploited by the developing countries.

##### Seed organization:

It is necessary to study the seed organization in advanced countries to ensure production of hybrid commercial silkworm seed in developing countries.

##### JAPAN:

Japan has organized its seed production on scientific lines. A seed legislation act is in force and a three tier multiplication of parent stocks is followed to maintain vigour of highly productive silkworm breeds.

Research institutions in Japan play a vital role in the evolution of high yielding breeds of silkworms. Breeder stocks are maintained here without loss of vigour by the highly competent silkworm breeders.

Prefectural Experimental Stations play a significant role in seed organization. Three tier seed multiplication programme of the parent stocks starts with these institutions. They maintain the silkworm stocks strictly conforming to the standards fixed by the breeder for the race. Both in great grand parent (P3) and grand parent (P2) stocks strict selection is ensured at the egg, larval and cocoon stages. In addition to these research stations, there are private egg production associations and companies which have well organized parent seed producing centres. Private egg producers

association has organized a breeding station exclusively to meet their demand of basic seed at Ami Town. This is headed by top level silkworm breeders. The annual requirement of P3 and P2 stocks is assessed and programmes drawn to supply the same.

Highly productive breeds with cocoon weight and shell weight of 2.5 to 2.22 grams and 0.55 to 0.5 grams are produced at P3 and P2 level respectively. These institutions supply the parent seed to the grainages who in turn supply them to certified cocoon growers.

At P1 level technicians from the grainages supervise the rearing of silkworms with the seed cocoon growers to ensure the cocoons free from disease. This periodical visit and constant touch with the farmers helps them to achieve high quality in parent seed cocoons. Strict standards are followed even at the time of purchase of these seed cocoons for the grainages. Only those cocoons which conform to standard of quality, healthiness and free from disease are accepted for seed preparation. Japan is supplying foundation hybrids for high silkworm egg production. These explain the superiority of Japanese breed with renditta of 5 to 6 and high cocoon yield.

#### CHINA:

China has paid great attention to seed production programme. Phenomenal growth in silk production in China during recent years may be attributed to the well organized seed production programme with a three tier multiplication of the parent seed.

Research institutes concentrate their efforts on evolving high yielding silkworm breeds. Once these are accepted by the Government, they are passed on to the 'Breeding Stations'. These institutions play a significant role in seed organization. Thus distinct roles are given to research and seed organization.

'Breeding Stations' are well equipped with mulberry plantation and all equipments required for maintaining the high standard of rearing of P3 stocks. Only 20% of cocoons are selected at P3 level to maintain breeder stock. At P2 level the selection criteria is 45 to 60%. High standards of rearing and selection is followed at all stages of growth of parent stocks. The cocoon quality at P3 and P2 level is high. The P2 DFLs are supplied to a group of branch P1 stations each having about 15 to 25 hectares of mulberry plantation. These P1 centres produce parent cocoon stocks. Because of this systematic seed organization, China has achieved a renditta of 8 to 10 in industrial cocoons.

#### U.S.S.R.:

U.S.S.R. has also organized a sound silkworm seed organization under the control of the Government. Only at P1 stage, the seeds are reared by the selected seed rearers attached to the grainages. Thus a link is established between the parent seed cocoon production and the seed growers as in Japan.

The three tier multiplication viz. basic seed, superior elite eggs and elite eggs production which correspond to P3, P2 and P1 seed is strictly practised. Research institutes decide about the combinations of hybrids and their pure race after extensive trial at the field level. They maintain the breeder stocks only to replenish the stocks at the breeding stations if required. They do not play any role in seed organization of the country.

Seed organization programme is the responsibility of breeding station. The maintenance of vigour of the breeder stocks and production of parent stocks which are vital links in seed organization, is well taken care of by a network of silkworm breeding stations. These stations are provided with all modern amenities and a well organized farm and manned by highly qualified silkworm breeders. Each breeding station is headed by the silkworm breeder at the level of Director who practically

attends to selection of various levels, by himself. Each station has a responsibility to maintain at a time only two silkworm races which form a combination for hybrid seed. The P3 stocks of Sheki-I & II, the popular races of Azerbaijan have cocoon weight of 2.0 to 2.5 grams and shell weight of 0.5 grams.

The silkworm breeding stations supply the P2 DFLs to the 'Breeding Farms' each having 10 to 15 acres of mulberry plantation. These breeding farms prepare P1 eggs (elite eggs) and supply the same to the grainages. The grainages supply the elite eggs to the selected collective farms which are specialized in seed cocoon production programmes. The farmers at these farms raise the (P1) parent seed cocoons. They are guided by the technical staff of the grainage, by constant visit and periodical technical guidance in silkworm rearing and sericulture hygiene. The seed cocoons harvested by these selected collective farms are subjected to selection by the grainage staff and only those which conform to the norms fixed for the race are accepted for seed production. About 40% of the total seed cocoons produced are only utilized for seed programme.

#### **SOUTH KOREA and BRAZIL:**

South Korea is following the same pattern of seed organization and seed production as in Japan. Brazil, even though has started sericulture late has almost reached self sufficiency in seed through Japanese assistance.

#### **INDIA:**

India, which is one of the leading developing countries in the world, has adopted a three tier multiplication in most of its sericulture states. In Karnataka, where multivoltine hybrid programme is followed, a well organized network of P3 and P2 centres have been organized to maintain the vigour of the parent stock and also to ensure disease free stocks. A separate seed area is organized for multivoltines. Here the P3 stock is maintained and multiplied by a network of farms. The farmers in this area can rear only multivoltine pure races supplied by government only according to 'Silkworm Seed Legislation Act'. All the parent cocoons required for industrial seed in the entire state is grown in this seed area by the farmers. This has helped the Government to concentrate its efforts of disinfection and maintenance of vigour of silkworm stocks. Considering this advantage, other states are also organizing seed zone or seed areas. It merits consideration whether such a system of seed zone be followed in other tropical countries.

Since 1975, Karnataka State has taken over to bivoltine silk production programme. A three tier multiplication programme has been drawn with supply of basic seed stocks from the research institutes. A network of P3 and P2 stations under Government control are playing a significant role in maintaining the vigour of stocks. Bivoltine seeds required for the hybrid programme are drawn from two sources viz. bivoltine seed area and the selected seed rearers who are selected from the different zones. One of the major constraints for the bivoltine programme is the occurrence of pebrine disease. Cocoons which are declared as disease free at the time of purchase reveal pebrine at moth emergence making the stock unfit for seed production. The silkworm rearers also feel that rearing of bivoltine races in tropical conditions is difficult. Bivoltines have low resistance as compared to multivoltines. Multi x bivoltine hybrid programme is taken over by the Government as a policy. The hybrids are superior in silk content, yield and recovery.

Private egg producers in Karnataka take very little care during seed production though the parent seed is kept free from disease by the efforts of the Government in seed zones and pebrine is not transmitted by the male parent.

In Jammu & Kashmir, a three tier multiplication is functioning. The state is importing seed from abroad to meet the shortage. West Bengal is growing multivoltine

nistari race with four season bound programme. The main hurdle for West Bengal switching over to multi x bi hybrid programme is that it is difficult to raise bivoltine silkworms.

One of the major differences between seed organization in India and other countries is the lack of coordination between the grainages and seed cocoon growers unlike in developed countries.

#### Seed Organization wanting in many countries

In most of the developing countries, seed organization is far from satisfaction. The parent stocks are multiplied continuously without adequate care to maintain their vigour. Often there is no distinction between the commercial breeds and seed breeds. Many times due to lack of seed legislation act or enforcement of quality control, seeds are produced by the farmers. The incidence of pebrine disease is rampant resulting in failure of crops and poor harvest as compared to those in the advanced countries. Thus seed organization to control the vigour of silkworm seed is wanted in some developing countries.

In many developing sericultural countries, the developed countries in recent years have come forward to assist in the development of sericulture. The donor countries always supply the eggs of the recipient country and purchase back the industrial cocoons. In this process, a sound seed programme is not developed by the recipient country and as such they depend for silkworm seed on the donor country forever.

Developing countries in the world now hold the promising key for sericulture industry due to low labour cost and availability of land for sericulture. But lack of technical support for organized seed programme, technologies for silkworm rearing, etc., continue to cause poor silk productivity in developing countries. A determined effort therefore should be made by this August Body to ensure technological skills from developed sericulture countries for a sound seed production programme in the developing countries. In this connection, it is also to be emphasized that high yielding breeds of silkworms which are the monopoly of the developed countries should be shared with the developing countries as the future of sericulture lies in these countries.

#### Problems of non-mulberry silkworms

Non-mulberry silkworms like *Antheraea mylitta*, *Antheraea pernyi*, *Philosamia ricini*, *Antheraea assamensis*, are grown on trees. They are also prone to pebrine disease. However, information on mode of transmission and contamination are still wanted. Pebrine is also causing alarming situation in the yield of cocoons in Indian tropical tasar. In these varieties even though mother moth examination is effective to check the disease, contamination aspect is difficult to control due to rearing of silkworms in open space. There is no control on production of disease free layings in tasar. 80% of the layings produced in India are by the tribal farmers themselves. Hence it is difficult to control the incidence and spread of disease. Some reports are available about the survival rate of pebrine spores in high temperature in tropical conditions. However, a thorough study in this regard is essential. Similarly, cross infective studies of pebrine spores between insects have to be studied. Even in muga silkworms, pebrine disease is causing heavy mortality. In eri silkworms, since they are reared indoors, effective control of pebrine disease can be effective.

In non-mulberry silkworms, no systematic hybridization programme is in practice. Expression of hybrid vigour between geographical races is not established. Non-mulberry moths being wild, they are difficult to hybridize in captivity. This is one of the major hurdles in the intercrossing of geographical races for exploitation of hybrid vigour.

Scientific seed organization is lacking in all the wild insects exploited for commercial production of silk. However, attempts have been made in India to organize P3, P2 and P1 centres for tropical tasar. Basic stations are controlled by the Central Government. These centres supply the disease free eggs to the state level Pilot Project Centres. They multiply the stock and supply them to the farmers. The tribal rearers are accepting these disease free layings because of two advantages: 1. they do not need to prepare the silkworms eggs; 2. they get silkworm eggs to hatch on a single day instead of different dates in their preparation due to erratic emergence of moths.

In muga, very recently a system of P3, P2 and P1 rearing has been introduced. P3 stocks are maintained at higher altitudes from which small quantities of cocoons are taken for multiplication for P2 at lower altitudes. After acclimatization to the lower altitudes, they are supplied to the farmers as P1 seed.

An organized Seed Legislation and a programme of Scientific Seed Organization may also be thought of for non-mulberry silkworms.

EFFECT OF A GROWTH PROMOTER IN MULTIVOLTINE AND  
RACES OF SILKWORM BOMBYX MORI

EFFET D'UN PROMOTEUR DE CROISSANCE CHEZ LES RACES BIVOLTINES  
ET MULTIVOLTINES DU VER A SOIE BOMBYX MORI

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Auxins, Gibberellins and other growth regulators are extensively used in plant to regulate the growth and to get plants of better yield. Information on the effect of growth promoters in animal system is very much wanting. Hence an attempt has been made to investigate the effect of the growth promoter Para Amino Benzoic acid (PABA) in silkworm *Bombyx mori*. To understand differential responses to PABA a bivoltine Kalimpong-A and a multivoltine Pure Mysore race were tested. Two different concentration of the chemical were employed. Mainly leaf dip method has been used for administering the chemical. The preliminary findings reveal that the bivoltine and the multivoltine would respond differentially to the chemical, in regard to Economic traits analysed.

Les Auxines, les Gibberellines ainsi que d'autres régulateurs de croissance sont utilisés d'une manière intensive chez les plantes pour contrôler la croissance et obtenir de meilleurs rendements. Les informations concernant les effets des promoteurs de croissance chez l'animal sont insuffisantes. Aussi a-t-on essayé d'étudier les effets du promoteur de croissance l'Acide Para Amino Benzoïque (PABA) chez le ver à soie *Bombyx mori*. Pour déterminer les différentes réponses au PABA, une race bivoltine Kalimpong-A et une race Pure Mysore multivoltine ont été testées. Nous avons utilisé deux concentrations différentes du produit. La méthode de l'immersion de la feuille dans le produit a surtout été utilisée. Les résultats préliminaires révèlent que la race bivoltine et la race multivoltine ont des réponses différentes, pour ce qui concerne les caractères économiques qui ont été analysés.

EVOLUTION OF HIGH YIELDING MULTIVOLTINE RACES OF SILKWORM  
BOMBYX MORI BY SELECTIVE HYBRIDIZATION

EVOLUTION DES RACES MULTIVOLTINES DE VER A SOIE BOMBYX MORI  
A RENDEMENT ELEVE PAR HYBRIDATION SELECTIVE

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*In order to evolve disease resistant multivoltine races of silkworm Bombyx mori suitable to tropical climates an attempt has been made utilising polyvoltine Pure Mysore race and bivoltine KA and NB<sub>18</sub> races by conventional breeding. The progenies obtained after reciprocal matings of these races resulted in varied cocoon colours in the F<sub>1</sub> and F<sub>2</sub> generations exhibiting the desirable qualities of both the parents. The analysis of the rearing performance of some of these lines following inbreeding revealed a marked improvement in regard to the effective rate of rearing and hatchability over the parents. The possible mechanism of inheritance of the said traits are discussed.*

*Afin de développer des races multivoltines de ver à soie Bombyx mori résistantes à la maladie et adaptées au climat tropical, nous avons fait un élevage conventionnel de la race polyvoltine Pure Mysore et des races bivoltines KA et NB<sub>18</sub>. La descendance obtenue après accouplement réciproque de ces races donne des cocons de différentes couleurs chez les générations F<sub>1</sub> et F<sub>2</sub> et possède les qualités souhaitées des deux parents. L'examen des performances d'élevage réalisées par certaines de ces souches après élevage consanguin montre qu'une nette amélioration est obtenue par rapport aux parents pour ce qui concerne le rendement de l'élevage et le taux d'éclosion. Les mécanismes possibles de la transmission de ces caractéristiques sont discutés dans cet article.*

STUDIES ON SOME MECHANOSENSITIVE HAIRS ON THE OVIPOSITOR  
OF THE SILKWORM BOMBYX MORI.

ETUDES DU ROLE DE QUELQUES SOIES MECANOSENSITIVES SUR  
L'OVIPOSITION CHEZ LE VER A SOIE BOMBYX MORI.

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Oviposition is a very interesting phenomenon in silkworms. Though studies have been carried out demonstrating the influence of chemical substances entering the reproductive tract of the female during copulation on egg laying through their action on the central nervous system, nothing is known about the role of sense organs in oviposition. Present studies showed that the hairs on the ovipositor play an important role in oviposition. These hairs could be classified into four types of which the type I hairs which are the longest and are peripherally distributed appear to be more important in oviposition. Studies are being carried out to elucidate the properties of these hairs.

L'oviposition est un phénomène très intéressant chez le ver à soie. Des études ont été faites qui démontrent l'influence de substances chimiques intervenant dans l'appareil de reproduction de la femelle pendant l'accouplement sur la ponte des oeufs par l'intermédiaire de leur action sur le système nerveux central, mais on ne connaît pas le rôle des organes sensoriels dans l'oviposition. Cette étude montre que les soies de l'ovipositeur jouent un rôle important dans l'oviposition. Ces soies peuvent être classées en 4 catégories. Les soies de type I qui sont les plus longues et qui sont disposées autour de l'ovipositeur sont les plus importantes dans l'oviposition. Des études sont en cours pour déterminer les propriétés de ces soies.

SYNTHESIS OF NEW MULTIVOLTINE BREEDS OF SILKWORM BOMBYX MORI  
FOR TROPICAL CLIMATES

OBTENTION DE NOUVEAUX HYBRIDES MULTIVOLTINS DU VER A SOIE  
BOMBYX MORI POUR DES CLIMATS TROPICAUX.

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By inbreeding the hybrids of Multivoltine Pure Mysore and Bivoltine NB<sub>18</sub> races of silkworm Bombyx mori an attempt has been made to evolve suitable multivoltine races which are robust and produce good quality and quantity of silk in tropical climates as in India. By continuous selection for desirable qualities and inbreeding for 10 generations it was possible to isolate three promising breeds G<sub>11</sub>, G<sub>15</sub> and G<sub>23</sub> having the desirable features of both the parents. The possible mechanism of linking the desirable traits of both the parents by genetic recombination during the meiotic events of the hybrids is discussed. The performance of these breeds exhibit marked improvement over Pure Mysore in the commercial traits such as shell percentage, filament length, cocoon yield and renditta. Further, the initial field trials revealed that these breeds are disease resistant and suitable for tropical climates.

Par croisement consanguin d'hybrides de la race multivoltine Pure Mysore et de la race bivoltine NB<sub>18</sub> du ver à soie Bombyx mori, nous avons essayé de développer des races multivoltines robustes pouvant produire une soie de bonne qualité et en quantité suffisante dans les pays à climat tropical comme l'Inde. La sélection continue des qualités souhaitées et le croisement consanguin de 10 générations ont permis d'isoler 3 souches promet-

teuses,  $G_{11}$ ,  $G_{15}$  et  $G_{23}$  possédant les caractéristiques souhaitées des deux parents. La possibilité de lier les caractéristiques souhaitées des deux parents par recombinaison génétique pendant la méiose chez les hybrides est discutée dans cet article. Les performances de ces souches montrent une nette amélioration par rapport à la race Pure Mysore pour ce qui concerne la richesse soyeuse, la longueur du fil, la production de cocons et le rendement. De plus, des expériences ont montré que ces souches sont résistantes aux maladies et sont adaptées aux climats tropicaux.

EVOLUTION OF NEW MULTIVOLTINE STRAIN OF SILKWORM (BOMBYX MORI L.)  
WITH SEX LIMITED LARVAL MARKINGS

EVOLUTION D'UNE NOUVELLE SOUCHE MULTIVOLTINE DE VER A SOIE  
(BOMBYX MORI L.) AVEC DES MARQUAGES LARVAIRES DEPENDANT DU SEXE

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At present, the females of multivoltine Mysore race are being used as female parent in the cross breeding programme with bivoltine race as male parent for the production of commercial seeds. Sexing the parents at the time of eclosion, involves a time consuming process and reflects on the economy, in the large scale production of hybrids seeds. The present investigation has been taken up to transfer w-chromosome with a translocated piece of 3rd chromosome from the bivoltine race (Zepere) where the female larvae carry Zebra markings, into the chromosomal complement of Mysore race. The hybrids of these parents were inbred upto 9 generations. In every generation, segregation with respect to the colour of the cocoon and hibernation features of the eggs were observed, in addition to the larval markings. The marked larvae were separated and the ones which spins yellow cocoons and moths which lay non-hibernating eggs were selected as one of the parents for the next generation. By continuous selection it was possible to fix this trait in one of the sublines with multivoltine features which also shows a marked improvement in the commercial qualities such as cocoon weight, shell weight, shell percentage, denier and renditta, over the traditional pure Mysore race. The advantages of the large scale multiplication of this strain in commercial breeding is discussed.

A l'heure actuelle, la race multivoltine de Mysore est utilisée comme parent femelle dans le programme de croisement avec

une race bivoltine pour la production commerciale de graines. Le sexage des parents au moment de l'éclosion est un procédé qui prend du temps et n'est pas rentable lorsque la production de graines d'hybrides se fait à grande échelle. Cette étude a été entreprise pour transférer le chromosome w avec un morceau transloqué du 3ème chromosome de la race bivoltine (Zepere) dont la femelle porte des marquages larvaires zébrés, sur le complément chromosomique de la race Mysore. Les hybrides de ces parents ont été croisés jusqu'à la 9ème génération. Dans chaque génération, nous avons observé une ségrégation sur la couleur du cocon et les caractéristiques d'hibernation des oeufs en plus de celle des marquages larvaires. Nous avons mis de côté les larves marquées et nous avons sélectionné comme parents de la génération suivante les larves à cocons jaunes et les papillons donnant naissance à des oeufs non-hibernants. Une sélection continue nous a permis de fixer cette caractéristique dans une des sous-souches possédant des caractères multivoltins. Cette sous-souche possède des qualités commerciales nettement supérieures à celles de la race Pure Mysore du point de vue du poids du cocon et de la coque, de la richesse soyeuse, du denier et du rendement. Les avantages de la multiplication à une grande échelle de cette souche à des fins commerciales sont discutées dans cet article.

INDIAN ENVIRONMENT / TROPICAL ENVIRONMENT  
AND SERICULTURE

ENVIRONNEMENT INDIEN / L'ENVIRONNEMENT TROPICAL  
ET LA SERICULTURE

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India is primarily tropical, and subtropical in environment except some temperate northern hills zone, for sericulture industry. Multivoltine breeds of silkworm must be bred for tropical areas while bivoltine would be useful for the northern temperate zone. Local breeds like pure Mysore, Nistari and Nistid are highly adapted to local conditions and are valuable germplasm, though new multivoltine breeds may be evolved and put to the test of time. Commercial crops may be taken using hybrids, cross combinations, polyhybrids and crosses of selected useful mutant strains. In general, there has not been any break-through in this industry in India though in one and half decades to two decades raw silk production has been doubled. There is much boast to the non-mulberry silks with respect to research and development. Mulberry silk more or less stagnates and India is nowhere as far as quality of Indian silk is concerned or the quality of cocoons produced. While Indian commercial cocoons give filament length of only a few hundreds per cocoon, Japanese, Chinese and Korean cocoons provide filament length in thousands of meters. Korea beat India to fifth position in raw silk production. Drawbacks and remedies are discussed to plan a ten fold increase in silk production in India. Work of the present author and other breeders and views of Japanese experts are reviewed.

A part quelques régions légèrement montagneuses du nord qui ont un climat tempéré, l'Inde est un pays à climat tropical et subtropical. Les souches multivoltines du ver à soie doivent être utilisées dans des régions tropicales alors que les souches bivoltines sont plus adaptées aux régions tempérées du nord. Des souches locales telles que Pure Mysore, Nistari et Nistid sont très bien adaptées aux conditions locales et sont des génératrices de bonne qualité mais de nouvelles souches multivoltines pourraient être introduites et testées. Des hybrides, des combinaisons de croisements, des polyhybrides et des croisements de souches mutantes sélectionnées sont utilisées à des fins commerciales. Bien que la production de soie ait doublé en 20 ans, l'industrie séricicole indienne n'a pas connu de bond en avant. L'accent a été mis sur les soies non-mûriers dans les domaines de la recherche et du développement. L'industrie de la soie mûrier stagne et l'Inde n'est pas compétitive du point de vue de la qualité de la soie et de la qualité des cocons produits. La longueur des fils de cocons indiens ne dépasse pas quelques centaines de mètres alors qu'au Japon, en Chine, en Corée, on obtient des fils de plus de 1000 mètres de longueur. La Corée se place en 5ème position devant l'Inde pour la production de soie grège. Cet article indique les mesures à prendre pour multiplier par dix la production de soie grège en Inde.

STUDIES ON THE EVALUATION OF TWO RACES OF SILKWORM  
BOMBYX MORI FOR TOXICITY AND MUTAGENICITY OF ZINEB

ETUDES DE LA TOXICITE ET DE LA MUTAGENICITE DU ZINEB SUR DEUX  
RACES DE VER A SOIE BOMBYX MORI PROVENANT DU C.S.R.T.I.

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Zineb (Zinc Ethylene bis (Dithiocarbamate), a broad spectrum fungicide extensively used to control fungal diseases of mulberry and other agricultural crops is analysed for its toxicity and mutagenicity in silkworm Bombyx mori. A Bivoltine race of Kalimpong-A (KA) and a polyvoltine race of Pure Mysore (PM) are used. Varied concentration of 400 ppm to 30,000 ppm were administered to different developmental stages of silkworm by using (i) Oral feeding, (ii) topical application and (iii) Sub-cutaneous injection method.

The results have demonstrated that the two races tested are more sensitive to oral administration of the chemical than to other modes of administration. Two improved lines have been isolated from the topically treated late V instar batches. The present findings of the improved mutant lines are herein discussed. In addition, the induction of dominant lethals against the chemical treatment at different stages of development is also discussed.

*Le Zineb (Zinc Ethylène bis (Dithiocarbamate)), un fongicide à large spectre très utilisé pour contrôler les maladies du mûrier et d'autres produits agricoles provoquées par des champi-*

gnons, est analysé pour sa toxicité et sa mutagénicité chez le ver à soie Bombyx mori. On a utilisé une race bivoltine de Kalimpong-A (KA) et une race polyvoltine de la race Pure Mysore (PM). Des concentrations allant de 400 ppm à 30 000 ppm ont été administrées à différents stades de développement du ver à soie, soit (i) par voie orale, (ii) soit par application topique, (iii) soit encore par injection sous-cutanée.

D'après les résultats nous avons constaté que les deux races testées sont plus sensibles à l'administration du Zineb par voie orale qu'aux autres méthodes d'administration. Deux souches améliorées ont été isolées à partir de lots de la fin du 5ème âge traités localement. Le présent article donne les résultats obtenus avec les souches améliorées et décrit l'induction de létaux dominants contre le traitement chimique aux différents stades de développement.

PERFORMANCE OF THE C.S.R.T.I. I TO VIII MULTIVOLTINE  
BREEDS OF SILKWORM BOMBYX MORI L. FOR TROPICS

PERFORMANCE DES RACES DE VER A SOIE BOMBYX MORI MULTIVOLTINES  
I A VIII DU C.S.R.T.I. SOUS LES TROPIQUES

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C.S.R.T.I. - I to VIII, eight breeds of silkworm were fixed which were multivoltine in nature and bred true, under a plan NSPS - plan No 2 (modified) using two exotic breeds Belakokonaya and Tashkashi and local pure Mysore races. The breeds gave reasonably expected yields, were giving a filament length which was significantly longer than the local multivoltine breed and has certain quantitative characteristics resembling the exotic parental breeds. Production data of the breeds has been described averaging their performance on the whole, under conditions prevailing in Karnataka in 1970. The breeds were evolved for exploitation, commercially.

Huit races de ver à soie multivoltines (I à VIII) du C.S.R.T.I. ont été établies par croisement selon le plan NSPS (plan n°2 modifié) en utilisant deux races exotiques Belakokonaya et Tashkashi et des races pures locales Mysore. Les lignées ont donné les rendements souhaités avec une longueur de fil plus grande que la race multivoltine locale et ont certaines caractéristiques quantitatives des races parentales exotiques. Nous décrivons les résultats moyens des souches obtenues dans des conditions régnant au Karnataka en 1970. Les races ont été améliorées pour l'exploitation commerciale.

PRELIMINARY STUDIES ON THE ARTIFICIAL HATCHING OF  
BIVOLTINE EGGS OF SILKWORM BOMBYX MORI BY CHEMICAL METHOD

ETUDES PRELIMINAIRES SUR L'ECLOSION ARTIFICIELLE PAR  
TRAITEMENT CHIMIQUE DES OEUFs BIVOLTINS DU VER A SOIE  
BOMBYX MORI

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