< CONSULTANT MISSION REPORT >

Expert Consultation on Promotion of Global Exchange of Sericulture Genetic Resources

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SUMMARY OF RECOMMENDATIONS

It is very important to share mulberry and silkworm germplasm information not only for the countries, practicing sericulture to produce silk but also for the countries using mulberry leaves as fodder for the domestic animals, mulberry fruits for food and other by-products for different purposes, for instance, in lowering the blood-sugar level in diabetic patients.

In order to promote the global sharing of sericulture genetic resources, it is necessary to document all the mulberry and the silkworm germplasm holdings with detailed passport information in the standardized format of characterization and evaluation in common languages for all countries.

One of the problems in sharing the information of silkworm germplasm resources is that some countries, especially China, do not have information data in common languages, which makes the exchange of information difficult.

It ought to be solved how to share the genetic resources with the newly developing countries, especially in Latin America and Africa, which are willing to develop sericulture but do not have any germplasm to exchange with the donor country. Therefore, FAO or ISC has to gather information from advanced countries in sericulture about the genetic resources which they can without any compensations and which they want to exchange with the equivalent materials.

Besides, for the newly developing countries, a training program for the technicians should be organized in breeding and maintaining the genetic resources, because it may not be utilized effectively the genetic stock without the proper technology.

It is essential to develop a global market information service for international silk trade covering market demand - country wise, fashion demand - season wise, along with other information on clothing behavior of people from different countries and competition from other textiles, which will help silk producing countries to regulate their silk production, exports and imports of silk yarn, fabrics, dress materials etc. FAO may provide funding for creation of web site, information on silkworm and mulberry resources in the world can be available, along with encouraging e-mail communication among the scientist in the field whenever any new discovery of new technique developed.

In conclusion, for the next step to promote sharing of germplasm in sericulture, it is prerequisite to establish a technical committee under FAO and ISC, to set up a standard format of recording data of the quantitative characters and technical terms on the mulberry and the silkworm in common language, including the international regulations to exchange the information and genetic resources.

Introduction

The sericulture that comprises cultivation of mulberry, silkworm rearing and post cocoon activities leading to production of silk yarn provides gainful employment, economic development and improvement in the quality of life to the people in rural area. Therefore, many developing countries like China, India, Brazil, Thailand, Vietnam, Indonesia, Egypt, Iran, Sri Lanka, Philippines, Bangladesh, Nepal, Myanmar, Turkey, Uzbekistan and some of the African and Latin American countries have taken up sericulture to provide employment to the people in rural area.

However, the developed countries in sericulture, namely, Japan, Korea, and China were not willing to share any information or genetic resources with the newly developing countries, keeping the silkworm germplasm in secret form, because they were worried about the catch-up by the other nations.

Now Japan and South Korea are encountering several challenges and difficulties to maintain and conserve the sericulture genetic resources. The number of researchers and budget involved in germplasm management has been reduced so dramatically that the lack of working force will eventually hamper the breeding and maintenance of genetic resources of mulberry and silkworm.

It was very timely for FAO and ISC to organize the meeting on promotion of global exchange of sericultural germplasm resources in Bangkok, Thailand in September 2002, considering that Japan and Korea have some difficulties to maintain less important silkworm and mulberry resources due to the decline of sericultural industry, caused by high cost of production. Once a genetic resource of silkworm or mulberry is discarded in a country, it means that the strain disappear in the world.

All the participating countries have agreed to the proposal of sharing the sericulture germplasm information and materials between countries but it is essential to process further steps for the promotion of sharing sericulture germplasm between the developed and the developing countries in sericulture.

2. Standard Format for Management of Sericulture Genetic Resources

1-1. Standard Format for Management of Mulberry Genetic Resources

It is highly essential to set up a standard format for management of the germplasm resources of mulberry and silkworm. Characterization of mulberry genetic resource determines the structural and functional attributes of the accessions for their genetic identity. The standard format of morphological investigation for mulberry germplasm is shown in Table 1. The comprehensive information on variability recorded helps breeders and users for effective crop improvement. The data need to be standardised in terms of terminology, measurement codes, encoding methods and data recording procedures and hence, characterization becomes mandatory and forms a bridge between conservation and utilisation.

A format for reproductive characterization of mulberry germplasm is presented in Table 2 and a format for productivity and economic characters of mulberry germplasm is given in Table 3.

Table 1. Morphological investigation of mulberry germplasm

Variety		Name		Number	
Origin		District		Pruning type	
Outline	Height				
	Tree type	Type			
		Shoot number			
		Shoot length			
	Stem	Curve or straight			
		Color			
		Tree skin			
Shoot	Type	Curve or straight			
		Stand or bending			
	Size				
	Length				
	Side shoot number				
	Internode	Length			
		Curve or straight			
	Skin color				
	Skin veins				
	Stoma ostiole	Morpha			
		Size			
		Protruding			
		Distribution			
		Number			
Winter bud	Morpha				

	Growth character		
	Size		
	Color		
	Bud scale	Number	
		Layers	
	Accessory bud number		
	Bud bract		
	Leaf rank		
	Leaf scar	Morpha	
		Rhombic	
		Size	
Young shoot	Size and length		
	Number		
	Color		
	Trichome		
Blade	Morpha	Round leaf	
		Lobed leaf	
	Growth character		
	Incision	Depth	
		Size	
		Lobed leaf number	
	Leaf apex		
	Margin of leaf		
	Leaf base		
	Leaf vein		
	Leaf color		
	Lustre		
	Coarse leaf		
	Wrinkle		
	Size	Leaf length	
		Leaf width	
	Trichome	Leaf surface	
		Leaf back	
		Leaf vein	
	Leaf area		
	Leaf thickness		
Tender leaf	Color		
	Coarse leaf		
	Trichome		
Leaf stalk	Growth character		
	Length		
	Width		
	Color		
	Trichome		
Stipule	Morpha		
	Color		
	Size		
References			

Table 2. Reproductive characterization of mulberry germplasm

variety		Name			Number	
Origin			District		Pruning type	
Monoecious or dioecious				Female and male for one flower or not		
Unisexual or bisexual flower				Flower head		
Female flower	Catkin	Morpha				
		Size	Length			
			Width			
		Number				
		Color				
		Flower number				
		Flower character				
		Flower stalk length				
	Flower	Flower cover	Morpha			
			Size			
			Trichome			
		Style length				
		Stigma	Morpha			
			Length			
			Trichome			
			Bulge			
			Color			
		Ovary	Morpha			
			Size			
Male flower	Catkin	Morpha				
		Size	Length			
			Width			
		Number				
		Color				
		Flower number				
		Flower character				
		Flower stalk length				
	Flower	Flower cover	Morpha			
			Size			
			Trichome			
		Flower filament	Morpha			
			Length			
			Color			
		Anther	Morpha			
			Length			
			Color			
		Pollen grain size				
Fruit and sorosis	Fruit	Structure				
		Size				
		Fruit stalk	Color			
			Trichome			
	sorosis	Structure				
		Size	Length			

			Diameter	
		Color		
		Taste		
		Number		
		Fructification		
		Drop character		
		Mature character		
References				

Table 3. Productivity and economic characters of mulberry germplasm

Variety		Tree years		Cut type		Investigation time	
growth	Budding time	Budding stage					
		Leaf apex opening stage					
	Leaf growth day	1st leaf					
		2nd leaf					
		3rd leaf					
		4th leaf					
		5th leaf					
	Flower open day	Female	Opening day				
		Male					
	Spring leaf	Growth duration					
		Mature time					
	Autumn leaf	Growth duration					
		New shoot stopping day					
		Harding day					
		Leaf yellowed day					
	Full year growth duration						
Budding ratio (%)							
Ratio of growth bud to growth-ended shoot let	Growth bud	Percent					
		Length					
		Size					
		Leaf number					
	Growth-ended shoot let	Percent					
		Leaf number					
Shoot	Single tree	Shoot number					
		Shoot length for one tree					
	Single shoot	Shoot length					
		Shoot diameter					
Ratioof shoot to leaf to fruit	Shoot						
	New shoot						
	Leaf						
	Fruit						

Yield quantity per leaf	Spring	Leaf number per kg	
		Weight per leaf	
	Autumn	Leaf number per kg	
		Weight per leaf	
Leaf quanti ty	Spring	Shoot let length per meter	
		Yield for one tree	
		Yield for one hectare	
		Investigation date	
	Autumn	Shoot let length per meter	
		Yield for one tree	
		Yield for one hectare	
		Investigation date	
Water content and wilting speed	Water content	Spring leaf	
		Autumn leaf	
	Water Evaporation rate	After 2 hrs	
		After 4 hrs	
		After 6 hrs	
		After 8 hrs	
		After 10 hrs	
		After 12 hrs	
References			

1-2 Standard Format for Management of Silkworm Genetic Resources

Though accurate data are not available on the silkworm germplasm in different countries of the world, there is every likelihood that some of these silkworm accessions are duplicated; for several countries might have exchanged some silkworm germplasm for silkworm breeding. In fact much of the genetic diversity of *Bombyx mori* is derived from the inbred lines of land races and elite stocks evolved by the silkworm breeders and also from hybridisation of different geographical races; mainly the Japanese, Chinese, European and tropical races, which are distinct for several economic characters.

Among the four geographical races, the bivoltine and univoltine races of temperate origin and multivoltine races of tropical origin differ widely and exhibit contrasting characters. The bivoltine and univoltine races produce high quantity of good quality silk, whereas the multivoltine races are hardy, tolerant to pathogen load and thereby resistant to diseases compared to the bivoltines but produce low amount of poor quality silk. Apart from a rich biodiversity of geographical races, there are also a large number of mutants.

A standard format for management of the silkworm germplasm resources is presented in Table 4, Table 5 and Table 6.

Table 4. Primary characters of silkworm genetic resources

Check item	Example of characters	Method or comment
Voltinism	Univoltine, bivoltine or polyvoltine	Number of eggs laid
Egg color of diapause egg	Purplish gray, greenish gray, gray, pinkish gray or others	After overwintering
Chorion color	White, muddy white, yellow and light yellow	After hatching
Moltinism	Trimolter, tetramolter, pentamolter	During larval stage
Body color of newly hatched larva	Dark brown and reddish brown	After hatching
Body color of last inster larva	Bluish white, yellowish white, reddish white, translucent, black, yellowish orange or moricaud	Last inster larva most gluttonous
Body shape of last inster larva	Thinner & longer, normal, thicker & shorter, bigger and smaller	Last inster larva most gluttonous
Larval body marking	Normal marked, pale marked, plain or mixed	Last inster larva most gluttonous
Abdominal larval leg color	White and yellow	Last inster larva most gluttonous
Cocoon color	White, green, light green, greenish yellow, yellow, golden yellow, vermilion, flesh-colored or others	After harvesting of cocoon
Cocoon shape	Fully narrowed bale, slightly narrowed bale, ellipse, longer ellipse, spherical, spindle, cotton like, sericine cocoon or others	After harvesting of cocoon
Cocoon wrinkle	Normal, dense, rough and flossy	After harvesting of cocoon
Pupal character	Normal, black pupa, black wing or naked pupa	After harvesting of cocoon
Marker gene	Anything known	Marker gene of egg, larva, pupa and cocoon should be described.

Table 5. Secondary characters of silkworm genetic resource

Check item	Example of characters	Example of characters	Method or comment
Hatchability versus total fertilized egg	Percentage (round off to one decimal places)	Percentage	Average of numbers counted
Number of eggs laid	Number (round off to two decimal places)	Number	Average of numbers counted from 5 egg batches
Duration of last larval instar	Number of days (round off to three decimal places)	Number of days	From first feeding of last instar larvae to mounting
Duration of larval stage	Number of days (round off to three decimal places)	Number of days	From brushing to mounting
Percentage of missing larva	Percentage (round off to one decimal places)	Percentage	=(Number of cocooning larvae / number of larvae at the beginning of 4^{th} inster) x 100

Table 6.Tertiary characters of the silkworm genetic resource

Check item	Example of characters	Method or comment
Cocoon weight	g (round off to three decimal places)	Average of values derived from 25 cocoons
Cocoon shell weight	cg (round off to two decimal places)	Average of values derived from 25 cocoons collected separately between male and female
Percentage of cocoon-shell weight	% (round off to two decimal places)	=(cocoon shell weight / cocoon weight) x 100
Cocoon-shell lousiness	Point (round off to three decimal places)	Average of values derived from 25 cocoons Standard photograph is compared to samples
Degumming loss of cocoon shell	% (round off to two decimal places)	Average of values derived from 25 cocoons = (cocoon shell weight – the weight after degumming) / cocoon-shell weight
Raw silk percentage	% (round off to three decimal places)	Average of values derived from 50 cocoons =gross weight of raw silk / (fresh cocoon weight x number of cocoons used for reeling test
Length of cocoon filament	Number (integer)	average of values derived from 50 cocoons =(raw-silk length x average number of cocoon fed at the same time to button during reeling) / total number of cocoons used at one times
Weight of cocoon filament	cg (round off to two decimal places)	Average value derived from 50 cocoons =gross weight of raw silk / number of cocoons used in reeling test
Size of cocoon filament	Denier (round off to three decimal places)	Average value derived from 50 cocoons =(gross weight of raw silk x 9000) / (raw-silk length x average number of cocoon fed at the same time to button during reeling)
Reelability of cocoon	% (integer)	Average value derived from 50 cocoons =number of cocoons used in reeling test / number of times of feeding in reeling test
Neatness defects of raw silk	Point (round off to two decimal places)	Standard photograph is compared to samples

2. Standarized Descriptor for Sericulture Genetic Resources

2-1. Descriptor for Mulberry Genetic Resources

Characterization of mulberry genetic resource determines the structural and functional attributes of the accessions and is highly essential for their genetic identity. The comprehensive information on variability recorded helps breeders and users for effective crop improvement. For choosing the donors for hybridisation programmes, the background information is highly essential. The detailed information is required to describe an accession.

Morphological characterization is mainly based on visual observation and wherever it is necessary it is supported by quantitative measurements. These characters are strongly heritable in nature and manifested equally in all the environments and hence used in the genetic identify of the accession and this also enable an easy and quick discrimination between the phenotypes. Thus, the characterization and estimation of the morphological variability provides useful measure of genetic diversity prevalent in the gene pool.

The knowledge of floral structure and reproductive behaviour of mulberry accessions are of utmost important to undertake any breeding programme for maximum utilization of genetic resources for future needs. Leaf is the vital organ in a plant where the major physiological activities take place.

Characterization and evaluation of mulberry genetic resources is being enforced in accordance with the manual which has already been enacted (Machii et al. 1997). The characterization and evaluation of each item is classified into three groups as primary characters, secondary characters and tertiary characters. Primary characters are morphological characters such as leaf and bud. Secondary characters contain agronomical characters such as sprouting and disease resistance. Tertiary characters include commercial characters on agricultural productions such as yield and quality. As for the details of each item, please refer to the home page or the publication.

Essential primary characters	9	items
Optional primary characters	37	
Essential secondary characters	6	
Optional secondary characters	12	
Essential tertiary characters	5	
Optional tertiary characters	1	
Total	70	

The seven participating countries for promotion of global exchange of sericulture genetic resources, namely, Bulgaria, China, India, Japan, South Korea, France and Italy are conserving 4,993 accessions in total of mulberry plants, as shown in the Table 1. Among more than twenty species in the genus Morus, *Morus alba* L. has been most widely distributed.

For some mulberry accessions, taxonomical revision of genus *Morus* should be undertaken at global level. There is an urgent need for congregation of all *Morus* species available in the world at one place, which will facilitate to revise taxonomical position of genus *Morus* at global level and to promote sharing of germplasm for the developing countries in sericulture.

In near future, new international organization should be established to collectively preserve and carry out unified investigation on the mulberry genetic resources. The control of the database should be carried out more efficiently which might be useful in complementing the preservation of genetic resources that are lost by unknown reasons in some countries. Moreover, the institute concerned with the genetic resources should be located at the minimum of two places (tropical and temperate zone), because the suitable environment is not equable for each mulberry genotypes based on their hereditary characters.

Table 7. Conservation of mulberry species according to the species in seven countries (Total: 4993 accessions)

Morus species	Bulgaria	China	India	Japan	S. Korea	France	Italy
Morus. bombycis Koidz	2	22		583	97		5
Morus latifolia Poir. (*M. lhu*)	-	-		349	128		14
Morus alba L.	67	754		259	105	47	25
Morus multicaulis Perr.	9	750		-	-	8	-
Morus atropurpurea Roxb	-	120		3		1	-
Morus acidosa Griff. (*M. australis*)	-	-		44	1		-
Morus indica L.	-	-		30	5		-
Morus rotunbiloba Koidz.		-		24		1	-
Morus kagayamae Koidz.	8	-		23	1	1	1
Morus mongolica Schneid		32		-	1		-
Morus nigra L.		1		2	3	6	1
Other Morus spp.	4	181		43	15	9	-
Unknown (Unclassified)	23	-		15	259		3
Total	113	1860	908	1375	615	73	49

2-2. Descriptor for Silkworm Genetic Resources

To promote utilization of silkworm genetic resources, the following activities are undertaken at the germplasm resources centre.

1) Characterisation of silkworm germplasm and data base generation.

2) Evaluation of silkworm germplasm for biotic and abiotic stresses in the

specific hot-spots

3) Evaluation of silkworm germplasm for yield potentials at multi-locations.

Silkworm races from different geographical regions exhibit considerable variations for several important heritable characters viz., egg and cocoon colour, shape and size, voltinism, larval markings, moulting behaviour. Similarly, there is distinct molecular differentiation at the genome level in different silkworm accessions. Therefore, a proper and exhaustive characterisation will help to identify the distinctness of different silkworm accessions through phenotypic and molecular markers; which will help selection of parents for silkworm breeding.

Through characterisation, the specific identity of each accession is maintained, which helps to distinguish the accessions. Characterisation is mainly based on the heritable quantitative and qualitative characters, viz. morphological, anatomical, cytological, physiological, biochemical and biomolecular aspects.

Evaluation of germplasm under abiotic and biotic stress conditions is very essential to identify promising germplasm for further utilization in specific crop improvement programmes. The promising germplasm are further tested under multilocational trial to assess the genetic potential and genotype x environment interaction and genotype stability.

In the preliminary evaluation the accessions are subjected to uniform treatment and their responses are evaluated from the performance. The preliminary evaluation trial is conducted for 3 crops to study the potential and stability of the characters. The silkworm breeds are also subjected for evaluation under different seasons.

After screening the silkworm germplasm through preliminary evaluation, the potent / selected accessions are subjected to screening against various biotic and abiotic stresses to identify tolerant / resistant breeds under hot spots / sick beds. The biotic stress includes various pathogens (protozoan, bacterial, viral and fungal). The results of such hot spots / sick beds evaluation indicate the most potential accessions / breeds which are tolerant / resistant to specific biotic stress. Similarly the selected silkworm germplasm after preliminary evaluation are subjected to abiotic stress, particularly the adverse climatic condition (high temperature and high humidity / high temperature and low humidity).

In conservation of silkworm genetic resources, as shown in the Table 2, Japan and China preserve a large number of silkworm strains, which reach more than one thousand for each country. It is assumed that there are more than 3,000 in the world. It should be mentioned that there exist a large range of differences between the number and the quality of the silkworm genetic resources each country possesses at present, and many of the germplasm have not been classified according to the origin and the voltinism etc.

Table 8. Silkworm strains according to the geographical origin

Geographical origin	Bulgaria	China	India	Japan	Korea S.	France	Italy
Chinese				121	96		
Japanese				104	90		
European				46	32		
Tropical				6	9		
Mutants				460+172	-		
Others				175+21	94		
Total strains	182	>1,000	357	645+460	321	64	130

3. Promotion of Global Sharing of Sericulture Genetic Resources

It is very important to share mulberry and silkworm germplasm information not only for the countries, practicing sericulture to produce silk but also for the countries using mulberry leaves as fodder for the domestic animals, mulberry fruits for food and other by-products for different purposes, for instance, in lowering the blood-sugar level in diabetic patients.

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