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Diversity, distribution and conservation of mulberry [*Morus* sp] in Himalayas

B. B. BINDROO, S. ROY CHOWDHURI AND M. K. GHOSH

Central Sericultural Research & Training Institute
Berhampore - 742101, West Bengal, India

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ABSTRACT

Biodiversity covers variety of flora and fauna, their ecological roles and the genetic variability they contain. Diversity characterizes most of the life forms. The Indian sub-continent is an important center of origin of diversity of nearly 160 domesticated plant species of economic importance. Mulberry (Morus sp) is one of them and is cultivated not only for sericulture but also for fruits, fodder, timber, fuel, wood etc. There are 4 species of mulberry viz., Morus indica, M. alba, M. laevigata and M. serrata occurring in India and are found through out the Himalayas from Kashmir in West to Assam in East. Because of its adaptabilty to cross pollination with no inter-specific reproductive barriers a vast range of diversity in the genetic stocks has crept in thereby rendering it highly heterozygous plant species as a result every plant being different from other in natural population. To augment the diversity in true sense the characterization of the texa is essential and the magnitude of diversity that has crept in the genetic stocks of the indigenous origin as regards to various qualitative characters, morphology, anatomy, propagation, reproduction, growth and biochemistry are presented in the paper. The information elucidated clearly signifies the wide range of diverseness in the indigenous mulberry genetic stocks. The conservation strategy unlike other field crops is yet to be refined for mulberry. However, means for conservation of diversity with probable risks in mulberry are discussed.

Key words: Conservation, distribution, diversity, mulberry

Biological diversity was a concept confined to the textbooks and among the biologists for long years. Now, it is figuring as an important item in the national and international agenda. Biodiversity refers to the variety and variability of all species of plants, animals and micro organisms together with the ecosystem in which they thrive. It is now widely realized that conservation of biodiversity is essential for achieving the much needed sustainable development. The fact is abundantly reflected in the conservation on biological diversity and agenda 21 of the Earths Summit held at Rio-de-Janeiro. Diversity characterizes most of the life forms and covers variety of Flora and Fauna including their ecological roles and the genetic variability they contain. There are as many as 12 bio-geographic and 9 botanical regions in the world. Indian region is considered as the third richest in the world after South America and Malaysia in the number of plant species. There are approximately 50,000 plant species. Out of this nearly 20,000 species are that of folowering plants. Nearly 5,000 plant species are endemic. IUCN (International Union for Conservation of Nature and Natural Resources) has estimated that about 25,000 plant species are on the verge of extinction in world. The flora of India is in varying degrees of threat. As many as 3000 plant species are threatened with extinction.

The Indian sub-continent is an important center of origin of diversity of nearly 160 domesticated plant species of economic importance. Mulberry (*Morus* sp.) is one of them and is cultivated not only for sericulture but also for fruits, fodder, timber, fuel, wood etc. Rich in floristic wealth, whole of the Himalayan region harbours countless flora including mulberry. Most of the area of this region is mountaneous with average altitude varying from 300 m to 9000 m above MSL. Nearly 3/4th of the available biodiversity in region is being utilized and cultivated by the tribal and poor people living in remote areas.

Mulberry plants in the Himalayan region are mostly found as huge and massive trees growing in hillsides, road sides and river beds. The trees upto 250 years of age are commonly found in this region. Because of its adaptability to cross pollination with no inter-specific reproduction barrier, the wide ranges of variations in the characters of these plants have crept in thereby rending it a heterozygous species. Every plant being different from the other in natural population. With this great deal of diversity it becomes difficult in this plant to gather the information and carry studies on spot regarding effect of different edaphic/environmental factors on the expression of genotypic characters for adjudging the variation. For this purpose and to preserve the known diversity for posterity, the collection of mulberry genotypes from diverse genetic sources, their conservation, evaluation and consequent documentation is of prime importance. Efforts in this direction are underway and at present there are about 20 centres across the country where mulberry germplasm is being maintained and evaluated and documentations made on biosystematic data to augument the known diversity in true sense.

MATERIALS AND METHODS

The source of data generated on the indigenous group of mulberry germplasm totaling 243 accessions at CSGRC, Hosur depict the magnitude of diversity that exists in mulberry (Thangavelu et al., 2000). This concerns to various qualitative characters as well as to various quantitative characters covering Morphology, Anatomy, Reproduction, Propagation Growth and Biochemistry. Besides, the information available on distribution of the indigenous species viz.

Email: bindroobb@gmail.com

M. indica, M. alba, M. laevigata and *M.serrata* that exist on the Himalayan tracts has been utilized for augumentation of the diversity and the strategies of conservation dealt.

The degree of diverseness that exists as regards to various qualitative characters in the group of indigenous germplasm resources has been calculated as percentage occurrence and is given in Table-1. This include information on branching nature, straightness of branch, colour of young and mature shoots, phyllatoxy, nature and duration of stipules, leaf characteristics and distribution of sex. The range of diversity concerning various quantitative characters related to morphology, anatomy, reproduction, propagation, growth and biochemistry given in table 2 - 7 respectively.

RESULTS AND DISCUSSION

The diverseness of the genetic stocks, clearly elucidate that excepting for the metric traits pollen viability (Table-4); laminar index and moisture content (Table-6) all the quantitative characters showed higher coefficients of variation and more than 60 characters were with coefficient of variations above 20% which is very significant in elucidating the diversity in this plant. The information thus clearly signify the wide range of diversness of the mulberry genetic stocks of indigenous origin.

Mulberry a perennial deciduous plant is reported to have originated in China, the primary center of plant origin (Vavilov, 1926). Mulberry is supposed to be native of Indo-chinese area and distributed in the lower sub-Himalayan region up to an elevation of 2,100 m. Hooker (1885) reported 4 species viz. *M. indica, M. alba, M. laevigata* and *M. serrata* occurring in India and which are found throughout Himalayas from Kashmir in west to Assam in East. On the Himalayan tracts mulberry is found in untrained tree type of scattered plantation generally growing on river bunds, road sides, boundaries of agricultural fields and mountain terraces. The wide spread incidence of shifting cultivation (Jhum cultivation in the hilly tracts) leads to depletion of forest plantation and mulberry is not exception. *M. alba* and *M. indica* are almost not available in natural forest areas (Thangavelu *et al.*, 2000). *M. serrata* is confined to North western Himalayan region which is also threatened. Thus, the conservation of mulberry genetic in field gene bank and *in situ* has become very much essential.

a. ***Morus indica*** L. plants are mostly oldest indigenous trees in the region found commonly on the Edges of descending mountainous ranges up to an altitude of 2,200 m above MSL in whole off the Himalayan belt including HP (Central Himalayas) and J&K. The species is commonly found in the localities of Chamoli, Garhwal and Kumaon hills. In Naubana and Chanda areas the stands of this species have been raised as forest plantations through seed material. The common varieties of the species are Sujanpur local found in sub-tropical to intermediate Himalayan belts besides Jungli-Tul & Kable-Tul in temperate Himalayas. It is locally known as Kalimpong local (unlobed) and Matigara local (lobed) in Kalimpong hill region (W.B.). The species is distributed in district Johrat and Mangaldoi district and on the banks of river Brahmaputra in Assam. In Meghalaya it is known as Moulai locally and is found in Khasi hills of Nangpoh district. The species also is prevalent in Manipur and Nagaland.

b. ***M. alba*** **L.** is mostly an earlier introduction and is reported to occur throughout India from plains to an altitude of 3,500 m above MSL. It is found cultivated in areas of Rispana, Boxar, Mothronwal, Champawat, Bijnoor, Laulatabad, Jogina, Gorakpur. There are trees of *M. alba* which are about 200 years old in Jolikot area. It has been raised as forest plantation in Naubana and Chanda areas. The most common local varieties of this species prevalent in Kashmir are Chattatul (Mirgund), Chattatul (Zaingeer), Brantul, Buta-Tul, Zaga-Tul and Ptsari-Tul etc.

c. ***M. serrata*** is not a common species in N-W Himalayas. Besides in Rajouri-Poonch sector of Jammu Division it is distributed in Chamba and Sarahan region of H.P. between 1,100 m to 2,400m. As per details availab le with the Botanical Survey of India, *M. serrata* is found distributed in altitude between 1,300 m to 1,900 m in the localities of Sitapur, Joshimath and Wan Bagigad in Chamoli Garhwal region in Uttar Pradesh. The species mostly remains associated with Oak. The historic sacred mulberry tree of Joshimath belongs to this species and is belived to be more than 1200 years old (Rau, 1967). The species is commonly known as Kimu and its leaf is used as a fodder. *M. serreta* is sparsely distributed in North East and is found in Umling Forests of Khasi Hills of Nagapoh district in Meghalaya.

d. ***M. laevigata*** is confined in northern parts of HP and bordering Jammu province ascending up to only 1,200 m above MSL. The species is not found in temperate belts of Himalayas. Locally known as Kumai in Udhampur area the species is also found around Dehradun. The trees are occasionally planted in village limits for its fruits. It is also found in Lataguri rain forest range in Jalpaiguri district and in Kalimpong hill region in West Bengal and is commonly available in Karbiang district of Assam. It is sparsely distributed in district of Thouball, Bishnupur and Churachandpur besides Khurkul locality surrounding Imphal district and is commonly found in Jiribam district in Manipur.

Table 1: Diversity of different qualitative characters of indigenous mulberry genetic resources

Sl. No.	Character	Percentage of occurrence
1.	Branching Nature	Erect (62%), Semierect (19%) Spreading (19%)
2.	Straightness of branch	Slightly curved (37%), Straight (63%)
3.	Colour of young shoot	Green (85%), Purple green (15%)
4.	Colour of mature shoot	Brown (46%), Dark brown (7%), Greenish brown (13%), Greenish purple (1%), Grey (1%), Greyish brown (2%), Grey green (14%), Purple (8%) Purple brown (7%), Purple green (1%).
5.	Phyllotaxy	½ (55%), ⅓ (7%), $^{2/5}$ (13%) . Mixed (25%)
6.	Stipule Nature	Foliacious (98%), Free-lateral (2%)
7.	Stipule Duration	Caducous (99.5%), Persistent (0.5%)
8.	Leaf Lobation	Deep lobed (7%), Medium lobed (18%), Shallow lobed (19%), Unlobed (56%)
9.	Leaf lobation (No.)	Zero lobes (56%), 1-5 lobes (36%), 6-10 lobes (8%).
10.	Leaf Nature	Heterophyllous (40%) Homophyllous (60%)
11.	Leaf colour	Deep green (62%), Green (38%)
12.	Leaf surface	Rough (17%), Slight rough (27%), Smooth (56%)
13.	Leaf texure	Chartaceous 47%, Corianceous 53%.
14.	Leaf apex	Acuminate 95%, Acute 3%, Caudate 2%.
15.	Leaf Margin	Crenate, 23%, Dentate 8%, Repand 1%, Serrate 68%
16.	Leaf base	Acute 1%, Cordate 61%, Lobate 5%, Truncate 33%.
17.	Leaf shape	Cordate 1%, Narrow ovate 14%, Ovate 64%, Wide ovate 21%.
18.	Distribution of sex	Male, 16%, Female 59% Bisexual : (MF)-Male Female 5% (MB) Male Bixexual 5% (FB) Female Bixexual 2% (MFB) Male Female Bisexual (13 %)

Table 2: Diversity of various morphological characters in indigenous mulberry genetic resources

Sl. No.	Character	Min	Max	Mean±SE	CV (%)
1.	Lenticel density sq. cm^{-1}	2.80	8.77	5.04±0.06	18.40
2.	Leaf length (cm)	9.10	36.53	19.28±0.29	23.10
3.	Leaf width (cm)	5.76	27.74	14.87±0.27	27.90
4.	Petiole length (cm)	1.62	8.83	4.57±0.08	26.13
5.	Petiole width (cm)	0.10	0.65	0.36±0.01	29.15

Table 3: Diversity of various anatomical characters of indigenous mulberry genetic resources

Sl. No.	Character	Min	Max	Mean±SE	CV (%)
1.	Stomatal size (sq. µm)	149.68	787.96	315.00±5.85	28.94
2.	Stomatal frequency (sq. mm)	277.31	1046.84	662.21±10.38	24.43
3.	Idioblast length (µm)	2.87	100.00	13.21±0.88	104.23
4.	Idioblast width (µm)	8.43	70.88	22.61±0.54	36.91
5.	Idioblast frequency sq mm^{-1}	8.63	34.62	16.02±0.25	24.08
6.	Palisade thickness (µ m)	34.48	104.60	57.51±0.81	21.91
7.	Palisade spongy ratio	0.49	1.33	0.85±0.01	17.65
8.	Spongy thickness (µ m)	37.55	173.18	69.01±1.02	23.10
9.	Upper cuticle layer (µm)	2.78	10.92	7.30±0.10	21.35
10.	Lower cuticle layer (µm)	1.65	10.24	4.32±0.09	33.99
11.	Upper epidermis (µm)	9.58	37.93	22.65±0.38	25.86
12.	Lower epidermis (µm)	3.64	25.29	9.00±0.20	33.90
13.	Leaf thickness (µm)	100.96	340.89	169.77±1.88	17.24
14.	No. of chloroplast sq. mm^{-1}	8.00	33.00	11.13±0.17	23.29

Table 4: Diversity of various reproductive characters of indigenous mulberry genetic resources

Sl. No.	Character	Min	Max	Mean±SE	CV (%)
1.	Male inflorescence length (cm)	1.46	11.30	3.62±0.18	46.30
2.	Female inflorescence length (cm)	0.88	9.94	2.47±0.11	62.31
3.	Bisexual inflorescence length (cm)	0.88	6.13	2.77±0.1502	36.78
4.	Male inflorescence width (cm)	0.36	1.22	0.72±0.0.02	24.50
5.	Female inflorescence width (cm)	0.39	1.17	0.71±0.01	22.39
6.	Bisexual inflorescence width (cm)	0.43	0.94	0.68±0.02	19.41
7.	No. of male flowers catkin^{-1}	18.33	171.00	44.87±2.42	50.37
8.	No. of female flowers catkin^{-1}	0.92	245.89	47.28±2.77	80.03
9.	No. of bisexual flowers catkin^{-1}	8.11	69.33	32.03±2.77	80.03
10.	Male flower peduncle length (cm)	0.39	1.89	0.91±0.03	35.39
11.	Female flower peduncle length (cm)	0.27	2.41	0.96±0.03	44.02
12.	Bisexual flower peduncle length (cm)	0.24	1.97	0.92±0.06	41.65
13.	Stamen length (mm)	0.97	6.39	3.56±0.09	23.91
14.	Anther length (mm)	0.44	1.56	1.00±0.02	19.02
15.	Pollen diameter (µm)	14.94	30.49	19.58±0.37	17.99
16.	Pollen viability (%)	55.21	99.67	90.45±0.85	8.92
17.	Style length (mm)	0.01	1.98	0.47±0.02	64.28
18.	Stigma length (mm)	1.23	9.73	4.32±0.11	34.62
19.	Fruit length (cm)	1.17	10.08	2.90±0.12	57.14
20.	Fruit width (cm)	0.51	1.51	0.93±0.01	21.04
21.	Fruit weight (g)	0.10	7.21	1.19±0.08	96.84

Table 5: Diversity of various propagation parameters of indigenous mulberry genetic resources

Sl. No.	Character	Min	Max	Mean±SE	CV (%)
1.	Survival (%)	10.00	96.67	71.03±1.32	24.29
2.	No. of Leaves/sapling (After 120 days of planting)	5.50	53.33	20.74±0.83	52.46
3.	Sapling length (cm)	17.17	137.17	64.96±1.62	32.49
4.	Fresh shoot weight/sapling	1.08	67.75	21.25±1.07	65.82
5.	Dry shoot weight/sapling	0.39	26.01	8.28±0.41	64.13
6.	Sapling diameter (cm)	0.33	1.12	0.79±0.01	16.94
7.	Total fresh biomass sapling^{-1}	5.42	146.58	48.55±2.36	63.51
8.	Total dry biomass sapling^{-1}	1.61	49.17	15.94±0.80	65.06
9.	No. of roots sapling^{-1}	2.83	20.50	9.52±0.21	29.07
10.	Fresh root weight sapling^{-1}	0.74	36.24	0.78±0.43	64.38
11.	Dry root weight sapling^{-1}	0.23	13.83	2.94±0.16	70.46
12.	Longest root length (cm)	13,17	54,33	29.09±0.60	27.05
13.	Root volume sapling (mm)$^{-1}$	0.75	35.00	8.37±0.41	64.33

Besides above four species, the species *viz., M. nigra* (black mulberry) and *M. rubra* are reported to occur in Jammu and Kashmir, as early introductions. *M. nigra* commonly known as Shah-tul is sparsely found throughout Kashmir and is known for its special sour tasty fruits. *M. rubra* occurs in the Bhaderwah and Ramsu areas of Jammu province (Hooker 1885). The conservation strategy depends on the nature of the material, objective and scope of activity (Frankel 1970). For most of the annual field crops and few of the orchard crops, methods have been evolved, refined and being used. But for some important crops including mulberry, methods are yet to be refined and attempts are, however, underway. Conservation of mulberry can be carried out in two forms *viz. in situ* and *ex situ. In situ* conservations are those that maintain germplasm in wild populations by paying the regard to natural ecosystem of which the conserved population are a part. Gene pool concepts in wider sense include natural as well as artificial stands of the plantation of both indigenous and exotic species. As mulberry, besides sericulturally important, is used as wood and timber for manufacture of various items the use will increase the range of utilizable species. Wild mulberry maintains its original characteristics best in the habitats to which it is adapted which necessitates the formation of natural reserves in appropriate climatic,

altitudinal and latitudinal zones. In temperature regions mulberry is grown as trees. Under social forestry mulberry can be well conserved as trees with wider spacing. In addition it can be raised all along the boundaries of cultivated crops, bunds of channel and roadsides. A suitable organizational framework and greater open mindedness for conservation of the germplasm in natural forests is needed. The rich wild mulberry flora covering Northern U.P., J&K and north-eastern Himalayas needs attention. However, the *in situ* conservation of mulberry involves its own set of risks and difficulties but can function as an added "Evolutionary insurance" for long germplasm availability.

Table 6: Diversity of various growth parameters (evaluatory) of indigenous mulberry genetic resources

Sl. No.	Character	Min	Max	Mean±SE	CV (%)
1.	No.of branches plant^{-1}	2.17	53.67	22.21±0.61	43.07
2.	Longest shoot length (cm)	52.17	248.83	152.04±2.04	20.88
3.	Total shoot length (cm)	190.67	6690.17	2307.47±78.38	52.93
4.	Internodal distance (cm)	2.68	9.15	4.64±0.07	24.73
5.	100 leaf weight (gm)	51.82	1352.26	4.26.83±16.02	58.50
6.	Lamina eight (gm)	0.51	16.77	4.68±0.19	63.87
7.	Petiole weight (gm)	0.06	1.68	0.56±0.02	57.12
8.	Laminar index %	74.79	95.23	89.04±0.17	2.97
9.	Leaf petiole ratio (length)	3.16	10.53	5.41±0.06	18.65
10.	Leaf petiole ratio (weight)	4.83	21.39	9.93±0.15	23.97
11.	Leaf yield/plant/crop (kg)	0.18	5.08	1.83±0.06	52.81
12.	Leaf shoot ratio by weight	0.83	1.93	1.22±0.01	14.91
13.	Moisture content (%)	61.79	76.20	70.11±0.15	3.39
14.	Moisture conent (%) after 6 hrs	40.79	71.67	59.51±0.38	9.90
15.	Moisture retention capacity MRC after 6 hours	30.22	85.83	64.16±0.66	16.05

Table 7: Diversity of various biochemical parameters of indigenous mulberry genetic resources

Sl. No.	Character	Min	Max	Mean±SE	CV (%)
1.	Chlorophyll-a	1.46	3.81	2.48±0.03	18.13
2.	Chlorophyll-b	0.25	1.30	0.58±0.01	32.74
3.	Total chlorophyll	1.87	4.91	3.06±0.04	18.30
4.	% soluble protein (Fresh weight)	1.45	9.46	2.57±0.06	35.91
5.	% Soluble protein (dry weight)	6.09	23.30	9.15±0.18	30.25
6.	% Soluble carbohydrate (fresh)	1.50	5.71	3.18±0.05	24.35
7.	% Soluble carbohydrate (dry)	5.62	17.18	11.34±0.15	20.95

In *ex situ* conservation the practical way of preservation to date is storage of mulberry germplasm that is, in a gene bank (artificial gene pool) which usually means a seed bank. However, for mulberry, seed storage is difficult or impossible, as the genetic integrity of a particular clone or genotype cannot be preserved due to high degree of heterozygosity. In mulberry only by vegetative propagation the inherited characteristics of the parental stocks can be perpetuated. Hence, mulberry can be preserved by field plantings and is by *in vitro* method. The conservation of mulberry in the field gene bank is simple and technically less demanding, but it requires vast resources like fund, manpower and land. Further, the collections in the field gene banks are exposed to natural disaster and attack of pests and pathogens. To overcome these, the alternative method is cryopreservation of vegetative buds. The possibility of storage of woody cuttings of scion material by cryopreservation which is successfully followed in other sericultural countries must be considered for long term preservation under Indian conditions and methods need to be standardized.

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