SHORT COMMUNICATION

Distribution and Variation of Mulberry Genetic Resources (*Morus* spp.) in the High Altitude and Cold Deserts of Ladakh Himalayan Region

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The loss of genetic diversity due to human activities has drawn the global attention for vegetational and floristic studies to develop biodiversity conservation programme in many countries including India. Mulberry (*Morus* species) is out breeding and highly heterozygous perennial tree. Its high biomass production and protein rich foliage nurture the sericulture industry in India besides it is extensively used in agroforestry and horticulture programmes. Mulberry is abundantly available under natural habitat in the Himalayan belt and under managed habitats of on-farm conservation throughout the country. The genus *Morus* comprises about 68 recognized species (Sanjappa, 1989). Presently there are about 1300 gene banks on agro biodiversity which are operating worldwide maintaining about 6 million germplasm accessions (FAO, 1998). Among the sericultural countries, China is holding largest mulberry germplasm collections (2600 accessions) followed by Japan (1375), India (1053), Korea (615) and Bulgaria (140) in the *ex situ* field gene banks. Vavilov (1926) placed genus *Morus* in China-Japan region for the centre of origin. The Centre of Diversity of mulberry exists in the entire Himalayan belt where the natural mulberry and their wild relatives exist in abundance upto elevation of 2200 m MSL extending between Indus and Brahmaputra rivers. Hooker (1885) reported four *Morus* species *viz., M. indica, M. alba, M. laevigata* and *M. serrata* occurring in India. Since then the distribution and variation of mulberry genetic resources in India including Andaman Islands have been systematically reported by several taxonomists and germplasm curators (Ravindran *et al.*, 1997 and 1999, Dandin *et al.*, 1995: Tikader *et al.*, 2001 and Chaurasia and Singh, 1996 and 2001). The Central Sericultural Germplasm Resources Centre, Hosur (Karnataka) is the National Active Germplasm Site (NAGS) for mulberry in India and is mandated to collect, characterize and conserve the mulberry genetic resources. This centre conducted more than 50 survey exploration trips across the country and collected more than 660 mulberry genetic resources. Ladakh region of Jammu and Kashmir state remained unexplored till recently. Hence, an attempt was made to explore and survey cold deserts of Ladakh region for collection of frost tolerant mulberry genetic resources and identify locations for mapping of mulberry genetic resources, so that long-term conservation strategies could be evolved.

The Ladakh region is popularly known as High Altitude Cold Desert. It lies between 32° to 36° North Longitude and 76° to 79° East latitude sprawls over 96,701 sq. km with a low population. The Ladakh Himalayan range is rockey, barren and devoid of soil.

The survey area comprise Leh, Kargil, Suru Valley, Shyok-Nubra Valley and the altitude in these regions ranges from 3000 m and above to 5000 m AMSL. During the first phase, survey route covered 250 km from Leh to Kargil (Suru valley). The important places and adjoining villages covered were Spitok, Lamagaru, Nimmo, Sospol, Nurla, Khalatse, Lamayaru, Bodhkarbu, Namikala (3720m), Mulbeck, Lochum, Pashkyum and Kargil. In the second phase the survey route covered nearly 260km from Leh to Turtok (Nubra valley) and 142 km from Leh to Panamik. The villages covered were Gangles, Khardongla (5602 m), Khardong, Khalsar, Diskit, Hunder, Parthapur, Biagdong and Turtok.

A total of 14 mulberry germplasm resources (districts Leh-10 and Kargil-4) were collected in the Ladakh area and out of which 5 collections belong to *M. indica* and seven collections to *M. alba* and two collections remain unidentified (Table 1). The mulberry in Ladakh region is basically identified from the leaf morphological variation, style and stigma characters, fruit colour and other genetic characters (Koidzumi, 1917).

The detailed variability for morphological and reproductive characters of the mulbery collections from two districts of Ladakh is given in Tables 2 and 3. The distribution of mulberry in the Ladakh valley was sporadic

Table 1. Mulberry collections from different regions of Ladakh (J & K)

Districts	Area surveyed	Collection (Nos.)	Species (No. of accessions)
Leh	Nimmo, Ranabirpur, Spitotk, Sospol Nurla, Gangles, Khardongla, Khardong, Khalsar, Hundar, Diskit, Parthapur, Biagdong, Panamik and Turtok	10	*Morus indica* (3) *Morus alba* (6) *Morus* species (1)
Kargil	Kargil, Pashkyum, Lochum, Mulbek, Namikala, Bodhkarbu and Khalatse	4	*Morus indica* (2) *Morus alba* (1) *Morus* species (1)

in nature. Mulberry population is mostly available adjacent to the villages on the hill slopes along the rivers and under the managed habitats of *on-farm* conservation. The diversity of *Morus* species was confined to two species namely' *M. indica* and *M. alba* mostly in the altitudes ranging from 2750-3310 m MSL. A long spell of sub-zero temperature in the Ladakh region forces mulberry trees in the dormant condition from October to February. The dormant buds get sprouted on the onset of spring during March-April along with the floral buds and during July the trees remain in full bloom with fruiting. The trees belonging to both the species were highly branched and short height comparative to the *M. laevigata* species. The adaptation to sub-zero temperature was predominantly seen by forming dormant buds in winter. Most of the trees had attained the age approximately between 50-150 years with the trunk circumference of maximum 12 feet. The trunk circumference and structure, leaf lobation, morphology, sex and reproductive characters varied greatly among the collections. The leaf apex was obtuse to acute incase of *M. indica* (Figure 1) and whereas *M. alba* collections have short acuminate leaf tips (Fig. 2). At Nurla the *M. alba* collections exhibited variation in leaf lobation with highly dissected leaves where the number of lobes ranged from 0-10 (Figure 2) and the internodal distance greatly varied among the population. Short internodal distance a desirable characters was recorded in the *M. alba* collection from Pashkum of district Kargil. However, the leaf phyllotaxy is 1/2 in all the collections. The female flowers had uniformly short styles with divericate, pubescent and spreading stigma. A total of 14 mulberry germplasm resources representing *M. indica* and *M. alba* collected during the present survey trip exhibited wide variation in respect of morphological and reproduction characters. The trees were predominantly dioecious female and rarely monoecious in nature. The monoecious trees had all categories of inflorescence *viz.*, pure male, pure female and bisexual in the same branches or different branches of the same tree with different degree of cleistogamous condition. Irrespective of the species, the female flowers had short styles with diveritcate and spreading stigma, which indicated the hybrid nature of the population between *indica* and *alba* types. According to the taxonomical classification of genus *Morus*, the *M. indica* L. group (syn. *Morus ausrtalis* P. and *Morus asidosa* G.) belongs to *Dolichostylae* (Long style >0.5 mm in length and connate at the base) and the fruit length is short and the colour is black with sour or less sweet in taste and *Morus alba* L. belong to *Macromorus* (short style < 0.5 mm in length and free at the base) and the fruit length is short and the colour is white, violet or pinkish with sweet (Koidzumi, 1917 and Rao *et al.*, 1999). However, the present collections, which belong to *M. indica* had short to moderate style length and sweet indicated the hybrid nature. The population studies of these variants will be useful for taxonomically revision of *Morus* spp. besides, conducting hybridization studies for exploitation of hybrid vigour for crop improvement. Intra and interspecific hybridization in *Morus* helps to incorporate desirable traits and to study inheritance pattern of genetic characters. Dominance of parental characters in the F_1 crosses of different intra and interspecific crosses of mulberry including *M. alba and M. indica* species have been reported by Dwivedi *et al.*, 1989 and Tikader and Rao, 2002.

The availability of the young seedlings on the sides of the water canals, bunds and riverbeds at Sanjak village in Kargil indicated high level of seed fertility due to monoecious condition of the trees where 90.8% seed germination was recorded (Fig. 3). However, seed development in some isolated female mulberry trees indicated possibility of apomictic lines and the studies on the embryological aspects of these lines will have great importance for development of new propagation methods in mulberry and crop improvement. Inspite of high seed fertility recorded, the sparse distribution of natural mulberry trees observed in the valley needs a

Table 2. Variability of mulberry germplasm collections from district Leh of Ladakh range (J&K)

Characters	Places and collection details						
	Sospol	Sospol	Nurla	Hunder	Hunder	Biagdong	Turtuk
Morus species	*M. alba*	*M. indica*	*M. alba*	*M. alba*	*M. alba*	*M. indica*	*M. alba*
Altitude (m) MSL	3140	3140	3100-3140	3310	3310	3140	3310
Age in years	50	100*	10-60	100	120	100	200
Tree population	2 trees	1 trees	50 trees	15 trees	25 tree	25 tree	1
Purpose	Fruit and fodder	Fruit and fodder	Fruit and fodder	Fodder and fruit	Fruit and fodder	Fruit and fodder	Fodder and dry fruits
Trunk girth	5.6 feet	9.00 feet	1:6-5.0 feet	4.8 feet	4.8-6.0 feet	9-11 feet	12.0 feet
Shoot colour	Brown	Pinkish Brown	Brown	Brown	Brown	Brown	Brown
Leaf lobation	Unlobed	Unlobed	0-10 lobed	Unlobed	Unlobed	0-2 lobed	Unlobed
Phyllotaxy	1/2	1/2	1/2	1/2	1/2	1/2	1/2
Leaf shape	Ovate	Ovate	Ovate	Ovate	Ovate	Ovate	Ovate
Leaf apex	Acuminate	Obtuse	Acuminate	Acuminate	Obtuse-Acumnate	Obtuse	Acuminate
Leaf margin	Serrate	Serrate	Serrate	Serrate	Serrate-Dentate	Serrato-denate	Serrate
Leaf base	Cordate	Cordate to truncate	Truncate-Cordate	Truncate	Truncate	Cordate	Truncate
Leaf surface	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth
Leaf texture	Charatacious	Charatacious	Charatacious	Charatacious	Charatacious	Charatacious	Charatacious
Leaf size (L/B) cm	11.2 / 9.00	11.5 / 8.30	8.5-12.3/ 7.2-8.6	11.50/9.20	11.50-12.5/ 9.10-9.20	15.30/12.8	13.50/9.00
Petiole length	4.00	5.00	2.10-6.00	4.30	4.00-4.30	5.30	4.20
Internodal distance	5.8	6.5	4.30-9.1	6.10	4.00-6.10	4.50	4.50
Sex	Dioecious-Female	Dioecious-Female	Monoecious-Male and Female	Dioecious-Female	Dioecious-Male and dioecious Female	Dioecious-male	Dioecious-Famale
Inflorescence length	2.5	2.0	2.5-2.8	3.20	2.50	2.50	2.0
Style length	Short	Short	Very Short	Short	Short	Short	Short
Stigma length	Short	Short	Short	Short	Short	Short	Short
Stigma type	Divaricate	Divaricate	Divaricate	Divaricate	Divaricate	Divaricate	Divaricate
Fruit length	3.10	2.10	2.60-2.80	3.20	2.50-3.20	3.20	2.60
Fruit colour	White	Black	White	White	Pinkish red	Black	White
Fruit taste	Sweet	Sweet	Sweet	Sweet	Sweet	Sweet	Sweet

case study for seed propagation under sub-zero temperatures at higher altitudes of Ladakh Himalayas. Probably the young seedlings generated during July-August months with fragile and weak root system do not survive the long spell of winter season with sub-zero temperatures particularly in sandy soils with high pH. Secondly, the meagre bird population in the high altitude region restricts spread of the germplasm resources in the valley.

The distribution of *Morus* species *viz., M. indica* and *M. alba* in the higher altitudes above 3000 m msl of the cold deserts of Ladakh Himalayas reported by the present survey and exploration opens new research lines to study the distribution and propagation of *Morus* species in the high altitudes with long spell of subzero temperatures. The absence of other *Morus* species viz., *M. laevigata and M. serrata* in the Ladakh Himalayas is rather intererting; which are otherwise well distributed in the lower altitudes of adjoining northwest Himalayan ranges (Jammu & Kashmir, Uttaranchal and Himachal Pradesh) and requires more scientific investigation by conducting more survey trips to Indus, Changtang, Zanskar valleys of Ladakh to map the distribution of *Morus* species in high altitudes and diverse geographical areas. The studies on adaptation of *Morus* species to frost resistance will have great importance in developing frost resistant breeding lines in mulberry, which is required for development of sericulture in the temperate regions.

The total forest cover in the Ladakh valley is just 0.02% (45110 sq. km) and the broad leaved angiospermic flora is highly negligible which is the main cause for the oxygen depletion in the Ladakh region. Seeing the possibility of survival of *Morus* species in the higher

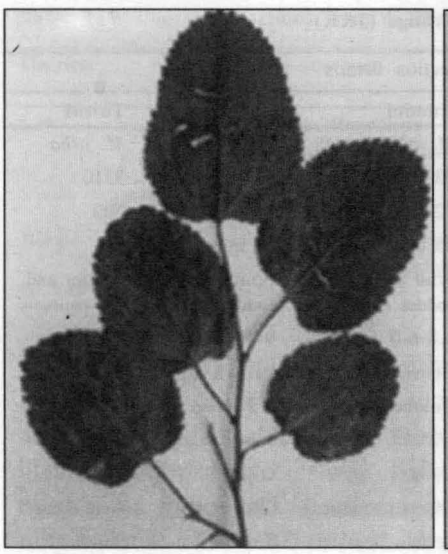

Fig. 1: Obtuse leaf apex of M. alba

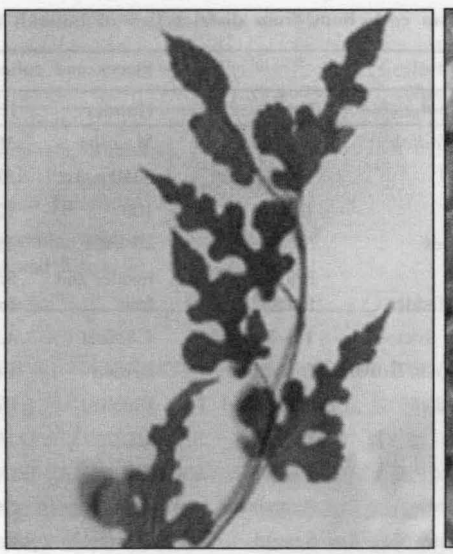

Fig. 2: Acuminate leaf apex and highly dissected leaf lobation of M. indica

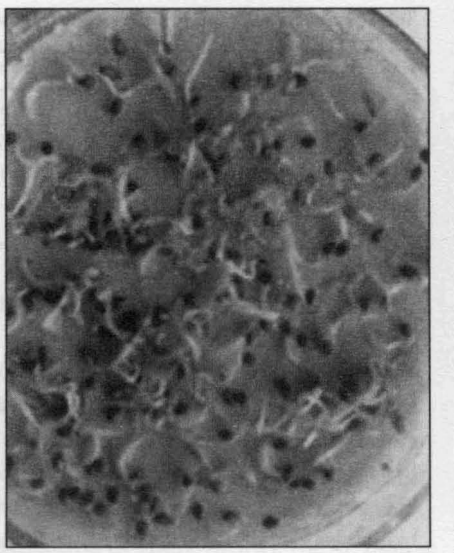

Fig. 3: Seed germination of M. indica at Sanjak

Table 3. Variablity of mulberry germplasm collections from district Kargil of Ladakh range (J&K)

Characters	Places and collection details Pashkyum-Brokhur	Pasqum-Brokhur	Sanjak	Bheema
***M.* Species**	***M. alba***	***M. indica***	***M. indica***	***M. indica***
Altitude	2950m	2950m	2840m	2750m
Age (approximately)	120	120	100	50
Tree population	3 trees	1 tree	About 100 trees	1 tree
Purpose	Fodder	Fruit and fodder	Fodder and fruit	Fruit and fodder
Trunk grith	5-5.4 feet	4.60feet	5 feet	2.7 feet
Colour of the shoot	Brown	Brown	Brown	Brown
Leaf lobation	0-5 lobed	Unlobed	Rarely 1 lobed	Unlobed entire
Phyllotaxy	1/2	1/2	1/2	1/2
Leaf shape	Ovate	Ovate	Ovate	Ovate to lanceolate
Leaf apex	Short acuminate	Acute	Acute	Acute
Leaf margin	Serrate	Serrato dentate	Dentate	Serrato
Leaf base	Truncate	Cordate	Cordate	Truncate
Leaf surface	Smooth	Smooth with dark green colour	Smooth	Smooth with dark green colour
Leaf texture	Charatacious	Charatacious	Charatacious	Charatacious
Leaf size (L/B)	7.8/ 3.0	12.0/9.10	19.50/15.80	12.0/9.10
Petiole length	2.30	4.50	6.20	4.50
Internodal dis.	3.80	5.00	6.10	5.00
Sex	Monoecious-(predominantly Female with few male flowers	Dioecious-Female	Dioecious-Female	Dioecious-male
Inflorescence length	2.80	2.50	2.50	2.50
Style length	Very Short	Short	Short	Short
Stigma length	Short	Short	Short	Short
Stigma type	Divaricate	Divaricate	Divaricate	Divaricate
Fruit length	2.50	3.20	3.10	3.20
Fruit colour	Pinkish White	Black	Black	Black
Fruit taste	Sweet	Sweet	Sweet	Sweet

altitudes of Ladakh, introduction of diverse *Morus* germplasm resources in the valley will be certainly a positive step towards the development of greening in the valley. The high branching, protein rich foliage and high fruit yielding varieties of mulberry will not only improve oxygen levels in the atmosphere but also support fodder and fuel resources besides, fruit based industry which will improves socio-economic conditions of the tribal population of Ladakh.

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