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Distribution, Variation and Conservation of Mulberry (*Morus* spp.) Genetic Resources in the Arid Zone of Rajasthan, India

A. Ananda Rao[1*] • S. S. Chauhan[2] • R. Radhakrishnan[1] • A. Tikader[1] • M. M. Borpuzari[1] • C. K. Kamble[1]

[1] Central Sericultural Germplasm Resources Center, Central Silk Board, Thally Road, Hosur-635 109, Tamil Nadu, India
[2] Research Extension Center, Central Silk Board, Intali Road, Fatehnagar-313205, Dist- Udaipur, Rajasthan, India

Corresponding author: * **anandarao_csb@yahoo.com**

ABSTRACT

Biodiversity mapping, collection, characterization and conservation of mulberry (*Morus* spp.) in different geographical regions of India have been given greater input. Three survey and exploration activities for diverse mulberry genetic resources in 19 districts of the arid zone of Rajasthan resulted in the collection of 75 accessions (*Morus indica* - 37; *Morus laevigata* - 23; *Morus alba* - 7; *Morus hybrids* - 8 accessions). The collections, which have wide variation in morpho-reproductive characters, are being conserved in the *ex situ* field gene bank of CSGRC, Hosur and evaluated for different leaf histological and growth parameters. Analysis of variance (ANOVA) on different leaf histological and growth parameters exhibited significant variation among the accessions. Promising accessions have been identified for developing drought-tolerant lines. Potential areas have been identified based on the variation and abundance of mulberry genetic resources for *in situ* conservation and promotion of sericultural activities.

Keywords: biodiversity, *ex situ*, mapping, morpho-reproductive variation, survey

INTRODUCTION

Mulberry (*Morus* spp. Family *Moraceae*) is a highly heterozygous perennial tree with high biomass production, and its protein-rich foliage is used extensively for sericultural, pharmaceutical, agro-forestry and horticulture programmes (Singhal *et al.* 2001; Ananda Rao 2003). The Indian gene centre is very rich in *Morus* species. Uttarakhand, National parks of Nandadevi, Namdapha, Kaziranga, Manas, Nokrek, Andaman and Nicobar Islands are the potential gene reserves for *in situ* conservation of mulberry (Ananda Rao 2003). In India, rich *Morus* diversity exists both under natural and managed habitats, which flourish well in on-farm conservation procedures promoting more than 0.6 million families of farmer/tribal livelihood development while conserving *Morus* biodiversity. In recent times seri-biodiversity is greatly threatened because of unlawful habitat destruction, natural calamities, fragmentation of forests, global climatic changes and social disruption and this large-scale genetic wipeout disturbs the coexistence of sericigenous flora and fauna (Ravindran *et al*. 1997). Enrichment of the *ex-situ* mulberry germplasm bank with wide genetic variation through surveys and exploration is a prerequisite for a mulberry crop improvement programme. The emphasis is on new breeding objectives such as stress tolerance which needs wild genetic resources from diverse geographical backgrounds. Therefore, CSGRC, Hosur has conducted more than 70 explorations covering the length and breadth of India and collected about 800 mulberry germplasm in these explorations (Sanjappa 1989; Dandin *et al*. 1995; Ravindran *et al.* 1997, 1999; Tikader *et al*. 2001; Ananda Rao *et al*. 2005, 2009). The efforts of mulberry germplasm curators yielded the conservation of 1136 diverse mulberry accessions in a field gene bank and 238 mulberry accessions in the national cryo gene bank at the National Bureau of Plant Genetic Resources (NBPGR) New Delhi (Ananda Rao *et al*. 2009). In recent times greater impetus was given to explore targeted areas like frost, saline and arid zones (Ananda Rao *et al*. 2005). The Rajasthan collections from arid zones which are well adapted to the local environment can be used in breeding programmes for drought tolerance. Besides, as mulberry is chiefly propagated for shade, fodder and fruit, particularly in Central and Western India, these collections can be used for developing varieties for non-sericultural purposes *vis-à-vis* promoting on-farm conservation of these genetic resources in their natural habitat.

Rajasthan is situated in the north western part of the Indian Union (23º 30' and 30º 11' North latitude and 69º 29' and 78º 17' East longitude). The total area of the state is 342239 sq. km and ranks first in terms of area in the country. It occupies 10.41% of the country's total area and yet its population is only 5% of India's total population. Phytogeographically Rajasthan falls partly under the Indogangetic Plains (Western Plains) and partly by the North Central Highlands (Aravalli range and Uplands and Thar deserts). The forest cover in Rajasthan is less than 10% (3 million ha) of the total area of the state and this is due to a lack of sufficient rainfall. The forest areas in Rajasthan are confined to low hill slopes in the north and Chambal Rivers in the south. The main forest types are tropical thorn types dominated by xerophytic forests (important species are Khair, Reunjha, Axle wood, Neem, Sandalwood, Acacia, Khejha, Palas, etc. Regarding diversity of crop plants, rich diversity occurs in Sorghum, Pearl Millet, Cowpea, Black gram, Green gram, Brassica, Sesame, Cucurbits, Forage legumes and Grasses (Zevan *et al*. 1982). A marginal increase in evapo-transpiration (ET) demand due to global warming will have a larger impact on the resource-poor, fragile arid zone ecosystem of Rajasthan and the resilience of plant biodiversity, including *Morus* species, will be greatly threatened. Hence, the preservation of plant biodiversity is essential for classical and modern (genetic engineering) plant breeding programmes. Moreover, this biodiversity provides a source of compounds to the pharmaceutical, food and crop protection industries. Against this backdrop the "Global Action Plan" was drawn representing the input of 198 countries, NGO, scientific experts and over 2000 recommendations were passed and about 20 priority

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areas for conservation and utilization of Plant Genetic Resources (PGR) were identified to meet the needs and aspirations of present and future (National Biological Diversity Act India, 2000). Green fodder is a great scarcity in Rajasthan, particularly during summers. Mulberry green leaves serve as a strategic forage source containing approximately 88% digestible organic matter, 15.20% crude protein, 9.85% crude fiber, 7.10% ether extract, 55.85% nitrogen-free extract and 12.00% ash with an average dry matter content of 32.38% in fresh leaves, adequate to meet the requirement as a cattle feed in the arid zone of Rajasthan (Kantwa *et al*. 2006).

MATERIALS AND METHODS

Survey and exploration for mulberry germplasm in Rajasthan

Three survey and exploration trips in Rajasthan were conducted covering 19 districts in collaboration with the Regional Research Centre (REC), Central Silk Board, Fathenagar and the Regional station of the National Bureau of Plant Genetic Resources (NBPGR) at Jodhpur, Rajasthan during 2002-2009. The survey route map and places of collection are given in **Fig. 1**. Random sampling procedures for the perennial cross-breeding trees after studying morpho-reproductive variability were followed maintaining the clonal individuality of each tree separately (Ravindran *et al*. 1997, 1999; Tikader *et al*. 2001; Ananda Rao *et al*. 2005).

Evaluation of mulberry genetic resources collected from Rajasthan

The Rajasthan collections were introduced in an *ex situ* field gene bank after initial establishment in the nursery for six months and assigned a National accession number by the NBPGR, New Delhi. The *ex situ* field gene bank (Latitude 12.45° N, Longitude 77.51°E, Altitude 942 m, red loamy soils with pH 7.8 and annual rain fall 700-1000 mm) is the National Active Germplasm Site (NAGS) for mulberry in India recognized by NBPGR, New Delhi. Four plants/accession are maintained in a row with a inter-row spacing 2.4 × 2.4 m as dwarf trees with crown height of 1.5 m. Recommended cultural practices for high bush and dwarf tree plantations are followed (Dandin and Sengupta 1988). After two years of establishment, the plants were pruned twice a year (February and June). Three plants were selected randomly for each accession (one plant /replication) and considered for data recording. The data on different descriptors (Metcalfe and Chalk 1979; Machii *et al*. 1997; Thangavelu *et al.* 1997) were recorded 70-90 days after pruning. The floral characters and *Morus* classification followed the method described by Koidzumi (1917). Different morphological characters were recorded mainly by visual observations (branching pattern, leaf shape, lobation, texture, phyllotaxy, stipule nature and duration, inflorescence shape and size, number of florets/catkin, fruit size), and by use of a Leica microscope (leaf trichome density, style and stigma length and pubescence, pollen diameter). Leaf shape was recorded by measuring the ratio of the length and breadth of the 7^{th}–9^{th} leaves counted from the apex. Sex expression was recorded by collecting fully bloomed catkins of different sexes in regular flowering seasons during Sep-Oct and Feb-Mar, 2006-2010 from 3 plants per accession.

For studying the leaf anatomical characters, fully expanded leaves from 7^{th}–9^{th} position from top of the longest shoot in descending order were collected in the morning at 9-10 am from 3-months-old shoots. From each leaf small rectangular pieces were excised from the central portion of the leaf blade avoiding veins and vein lets (Metcalfe and Chalk 1979; Tikader and Ananda Rao 2001; Ananda Rao *et al*. 2003) and preserved in FAA solution (formalin 5 ml, glacial acetic acid 5 ml and 70% ethanol 90 ml-Hi-Media Laboratories Pvt. Ltd, Mumbai, India). Studies on stomata and idioblasts were conducted by taking a thin layer of Wimbley's quick fix impressions on the abaxial (lower) and adaxial (upper) surface of the leaf, respectively and observed under a Leica Leitz, DMRB Wetzlar microscope. Stomata and idioblasts were counted per unit area and the frequency per mm^2 was calculated. For observing the cuticle, epidermal, palisade and spongy mesophyll, leaf thickness and idioblast length and breadth, thin (<250 µm) hand sections were made using stainless steel razor blades (Super Max) and observed under Leica Leitz, DMRB Wetzlar microscope after staining with 1% safranine and mounted in 50% glycerin (Hi-Media Laboratories Pvt. Ltd.). Chloroplast number per stomata was counted using epidermal peelings of freshly collected leaf samples and stained with 2% potassium iodide-iodine solution (Hi-Media Laboratories Pvt. Ltd.) and observed under a microscope. A total of nine mulberry leaves (three leaves from each plant/replication) collected randomly were considered for data recording of all the leaf histological parameters. Nine microscopic observations were recorded for each parameter and the data was subjected for statistical analyses like mean, standard error (SE), co-efficient of variation (CV %) and analysis of variance (ANOVA) for completely randomized design to determine the significance of treatment means using statistical package developed by Indostat Service Ltd, Hyderabad, India.

Different growth and yield attributing parameters of mulberry accessions were recorded after 70-90 days pruning in two seasons. The total number of shoots/plant were harvested from the basal node and used for counting the number of primary shoots/plant considering three plants for each accession. The longest shoot which attained maximum growth in the plant was considered for assessing the length of longest shoot and the total length of all the shoots were taken for measuring the total shoot length of each plant. The largest leaf at 7^{th}-9^{th} position from the top was considered for measuring and weighing the lamina length, breadth and weight. For recording 100-leaf weight, an equal number of leaves from the top leaving the tip, middle and bottom portion of the longest shoot were considered. The total aerial biomass of the plant was determined considering shoot weight along with the foliage; the entire foliage was harvested and total leaf yield was calculated. Moisture content of the excised leaves and moisture retention capacity after 6 hours' storage were determined using 25 leaves per accession and per replicate by a gravimetric method (Susheelamma *et al*. 1992). Three plants per each accession (one plant/replication) which are maintained in a row in the mulberry *ex situ* base collection were selected randomly for data recording on different yield attributing parameters. Statistical analyses like mean, standard error (SE), co-efficient of variation (CV %) and ANOVA was used to determine the significance of treatment means using statistical package developed by Indostat Service Ltd, Hyderabad, India.

RESULTS AND DISCUSSION

A total of 75 mulberry genetic resources (37 *M. indica*, 23 *M. laevigata*, 7 *M. alba* and 8 different *Morus* hybrids) both in natural and managed habitats (**Table 1**) were collected. *M. serrata*, which is endemic and abundantly available under natural distribution in the Himalayan region, is totally absent both under natural and managed habitats of arid and semi-arid regions of Rajasthan. The local landraces collected during the survey revealed wide variability of morpho-reproductive characters (**Figs. 2-4**) and possess valuable genes that can be exploited for developing region-specific and stress-tolerant varieties.

District-wise details of mulberry collections and variation

Jaipur

Survey was conducted in villages near Khoni, Banskho, Bassi, Dausa and Khatholai of Virat Nagar Tehsil and two local varieties belonging to *M. indica* were collected. The collection (AR2002/1.1) from Khoni is shallowly lobed and slightly rough and while that from Khatholai (AR2002/1.11) has deep-lobed leaves with a rough surface, acuminate base and serrate margin. The trunk girth is 4.3 m and tree height is approximately 18.29 m. The survey team located more than 25 trees in this area. The sex expression is mostly female with black fruits. Five collections were made from Durgapur area: *M. laevigata*, *M. indica* and *M. alba*. The *M. laevigata* collections were female in full bloom. The fruits

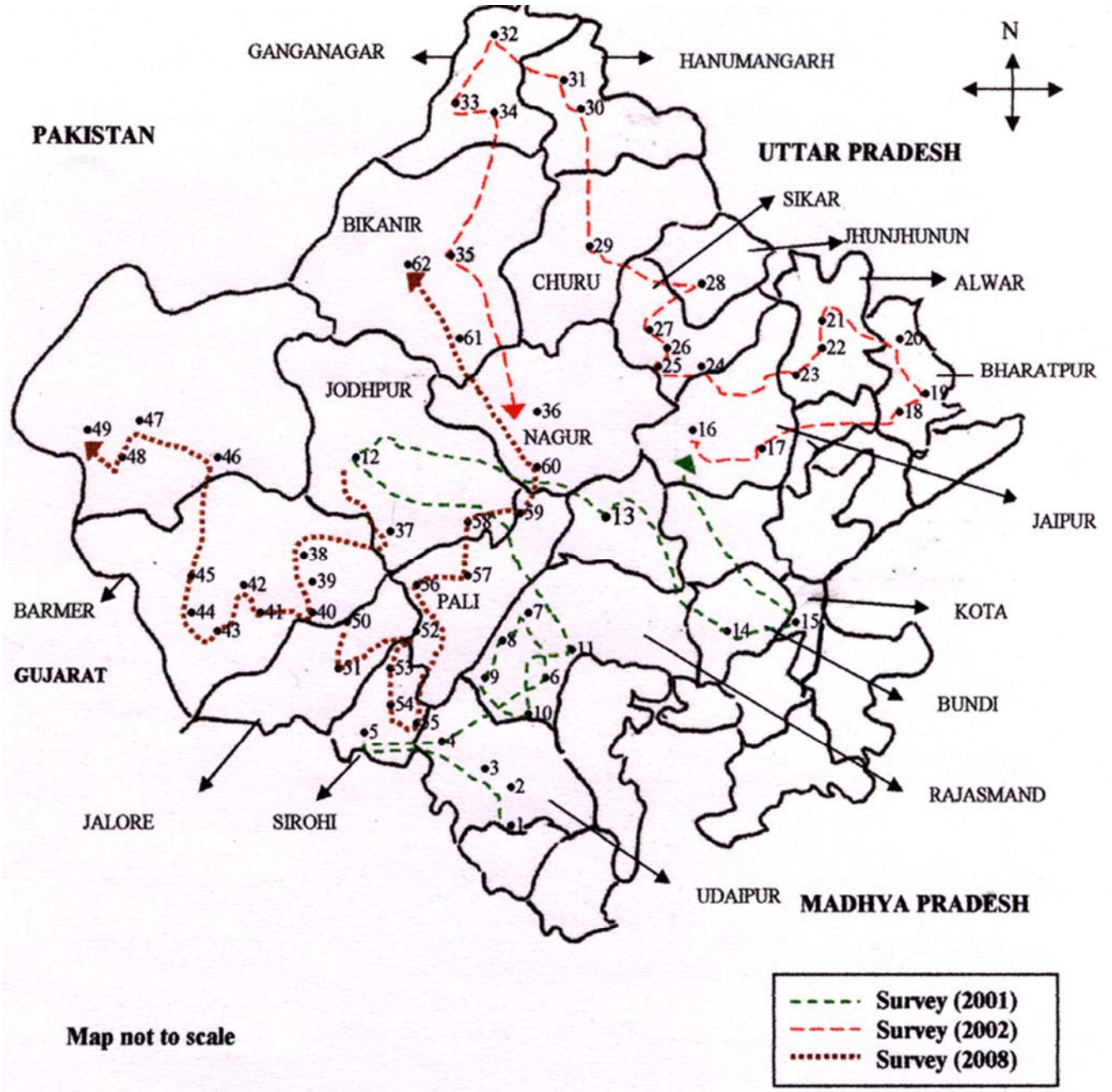

Fig. 1 Route map and places of collection of mulberry genetic resources in Rajasthan.

1	Alsigarh	17	Banskho	33	Jaitsar	49	Sam
2	Kakad (Jhadol)	18	Keolodeo	34	Suratgarh	50	Mokalsar
3	Goran (Jhadol)	19	Bharatpur	35	Bikaner	51	Jalor
4	Badagaon	20	Deeg	36	Nagur	52	Sumerpur
5	Mount Abu	21	Alwar	37	Dhawa	53	Shivganj
6	Nathdwara	22	Siliserh	38	Kalyanpur	54	Sirohi
7	Olader (Kumbalgarh)	23	Sariska	39	Samdari	55	Pindwara
8	Vardada (Kumbalgarh)	24	Ringus	40	Siwana	56	Pali
9	Oglat (Kumbalgarh)	25	Khatu	41	Asotra	57	Sojat
10	Haldigati	26	Palsana	42	Balotra	58	Bilara
11	Rajnagar	27	Sikar	43	Sindari	59	Jaitran
12	Mandore	28	Jhunjhunun	44	Barmer	60	Martha
13	Puskar	29	Churu	45	Shiv	61	Deshnok
14	Bundi	30	Tibi	46	Devikot	62	Bikaner
15	Kota	31	Hanumangarh	47	Jaisalmer		
16	Durgapur	32	Sri Ganganagar	48	Desert National Park		

are pale yellow and taste very sweet. Leaf shape is wide ovate and coriaceous in texture.

Bharatpur

An extensive survey was done in Bharatpur, Deeg-Dhaulpur Circuit areas. The Keolodeo National Park, a unique bird sanctuary, is the abode for more than 375 bird species; mulberry could not be located as seen in the Kumbalgarh area of Rajasthan. Introduction of high fruit-yielding mulberry germplasm in this area will have great promise for the spread and distribution of the local landraces. The survey

Table 1 Survey and exploration details in Rajasthan

Districts covered	Area surveyed and place of collection	Year of collection	Number of collections	*Morus* species
Udaipur	Kakad, Jhadol, Goran, Udaipur	5-10-2001 to 24-10-2001	6	*M. indica* - 5 *M. laevigata* - 1
Sirohi	Mount Abu, Manduva		2	*M. indica* - 1 *M. laevigata* - 1
Rajsamand	Nathdwara, Kumbhalgarh, Haldigati, Oglat, Olader, Vardada		8	*M. alba* - 3 *M. indica* - 1 *M. laevigata* - 2 *M. species* - 2
Jodhpur	Balasamand, Mondor		1	*M. laevigata* - 1
Ajmer	Puskar		2	*M. indica* - 1 *M. laevigata* - 1
Kota	Kota, Ramganjbalaji		4	*M. indica* - 1 *M. laevigata* - 1 *M. species* - 2
Bundi	Bundi, Mangli		3	*M. laevigata* -1 *M. species* - 2
Jaipur	Durgapur, Jaipur, Dausa, Khoni, Banskho, Khatholai		7	*M. alba* - 1 *M. indica* - 4 *M. laevigata* - 2
Bharatpur	Deeg, Bochaka, Keolodeo National Park	14-11-02 to 29-11-2002	2	*M. indica* - 1 *M. laevigata* -1
Alwar	Shilished, Narayana villa, Sariska National Park		3	*M. species* - 2 *M. laevigata* -1
Sikar	Palsana Govt. nursery		4	*M. alba* - 1 *M. indica* - 2 *M. laevigata* - 1
Hanumangarh	Kola		1	*M. indica* hybrid - 1
Sri Ganganagar	Multipurpose school, Dada nursery, Sri ram nursery, Central State Farm of Jaitsar, Suratgarh		8	*M. alba* - 2 *M. indica* - 2 *M. laevigata* - 4
Jodhpur	Jodhpur, Pal, Bilara	12-11-2008 to 28-11-2008	4	*M. indica* - 4
Barmer	Kalyanpur, Samdari, Siwana, Asotra Balotra, Sindari, Hodu, Kurla, Barmer, Barkha, Gunga, Khoral, Nimbla, Bayter and Shiv, Tapan, Mokalsar		2	*M. indica* - 1 *M. laevigata* - 1
Jaisalmer	Devka, Fatehgarh, Konai, Sankra, Devikot, Jaisalmer, Dabla, Sam road, Desert National Park		1	*M. indica* - 1
Jalor	Sakarna, Umedpur, Ahor, Charli, Godhan, Balwara, Bishngarah, Jalor, Malpura		4	*M. indica* - 2 *M. laevigata* - 2
Udaipur	Fathenagar		1	*M. indica* - 1
Sirohi	Posaliyan, Utaman, Atwada, Pindwara Road, Bhensawara, Malpura, Sumerpur, Shivganj, Paladi, Sirohi		4	*M. indica* - 2 *M. laevigata* - 2
Pali	Takhatgarh, Mandwa, Jaitran, Sirohi, Posalia, Sumerpur, Sanderaw, Gundoj, Pali		4	*M. indica* - 4
Nagur	Sojat, Bilada, Bassi, Mertha, Run, Alay, Gagura, Butaty, Junjala, Nagur		-	-
Bikaner	Parwa, Gogolao,Warani, Ratadi, Nokha, Bhamatsar, Rasisar, Deshnok, Palana, Gangasahar and Bikaner		4	*M. indica* - 3 *M. laevigata* - 1

team collected two mulberry local landraces at Deez and Bochaka areas in Bharatpur district outside the Keolodeo National Park. The varieties belong to *M. laevigata* (AR2002/1.2) and *M. indica* (AR2002/1.7); both accessions are lobed.

Rajasamand

Eight mulberry germplasm collections from the Rajsamand district exhibited maximum variability with respect to morpho-reproductive characters. A good number of trees (30 numbers) belonged to *M. alba* growing both in wild and cultivated form in Olader (Kumbalgarh) (**Fig. 3**). A huge wild tree of *M. alba* with a trunk girth of 5 m and height of 7.62 m was observed at Olader (Kumbalgarh) which may be of few hundred years old. One collection at Oglat (Kumbalgarh) at an altitude of 1020 msl possessed thick coriaceous, smooth and glossy leaves. Collections from the Vardada area had exclusively male flowers. The Nathdwara collections belonging to *M. laevigata* exhibited wide variability in leaf shape and texture with shorter styles (<1 mm) and long fruits with size varied from 8-9 cm (*M. laevigata*) and 2.5-4.5 cm (*M. alba*) (**Fig. 4**). The leaves belong to *M. laevigata* are highly lobed (10 lobes) in Nathdwara collection.

Hanumangarh

The exploration team surveyed Kola village near Tibi and collected one local landrace belonging to *M. alba* and *M. indica* hybrid (AR2002/1.16). There are more than 1000 mulberry trees, cultivated exclusively for shade and fodder. The trees have attained a height of more than 15 m. The leaf lobation is heterophyllous (0-3 lobed) and slightly rough. The Department of Forestry (Kola farm) is propagating mulberry cuttings, which are hardened in greenhouses and supplied to farmers for cultivation.

Sikar

Palsana, Ringus, Laxamangarh and Khatu are the potential areas for the availability of different local landraces of *Morus* species. Four local landraces of mulberry belonging to *M. indica* (AR2002/1.14 and AR2002/1.15), *M. alba* (AR2002/1.12) and *M. laevigata* (AR2002/1.13) were collected in these areas and all are females. *M. indica* varieties, which are widely distributed in the village, are mainly cultivated for shade, cattle feed and fruit. The Palsana Government Horticulture Nursery (Nutritional Garden) is raising mulberry saplings for distribution to the farmers. The Collection from Palsana (AR2002/1.15) is grown from open-

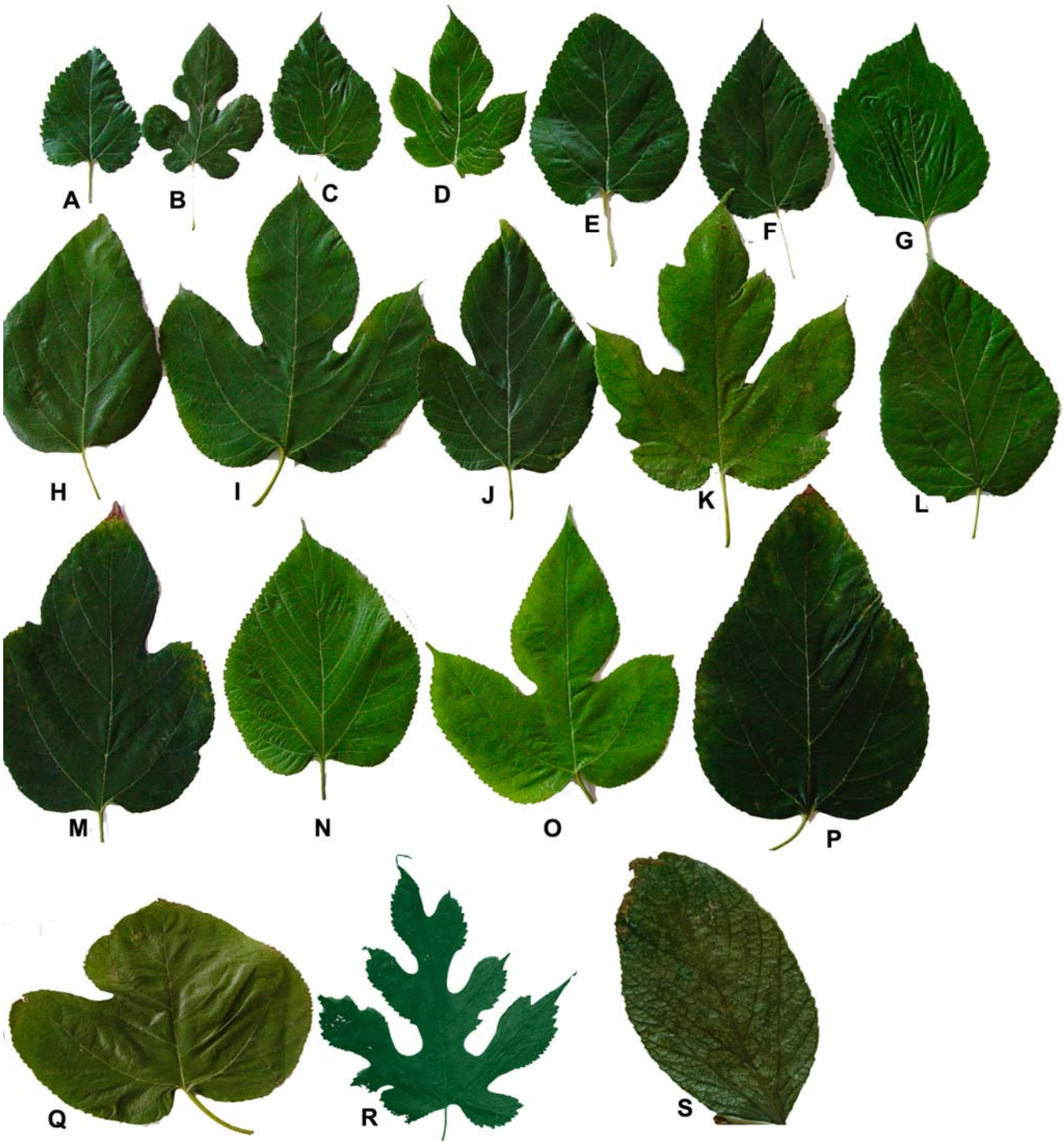

Fig. 2 Variability of leaf characters of Rajasthan collections. (**A**) Mount Abu, Sirohi district, *M. laevigata*; (**B**) Kumbalgarh, Rajsamand district, *M. alba*; (**C**) Alsigarh Udaipur district, *M. indica*; (**D**) Alwar, Alwar district, *M. laevigata*; **E**-Khakad, Udaipur district, *M. alba*; (**F**) Badagaon, Udaipur district, *M. indica*; (**G**) Mount Abu, Sirohi district, *M. indica*; (**H**) Durgapur, Jaipur district, *M. laevigata*; (**I**) Kumbalgarh, Rajsamand district, *M. laevigata*; (**J**) Deez, Bharatpur district, *M. laevigata*; (**K**) Bundi, Bundi district, *M. laevigata*; (**L**) Durgapur, Jaipur district, *M. alba*; (**M**) Ganganagar, Shri Ganganagar, *M. laevigata*; (**N**) Jaitsar, Shri Ganganagar, *M. laevigata*; (**O**) Durgapur, Jaipur district, *M. laevigata*; (**P**) Pushkar, Ajmer, *M. laevigata*; (**Q**) Nathdwara, Rajsamand district, *M. laevigata*; (**R**) Siwana, Barmer district, *M. laevigata*; (**S**) Sirohi, Sirohi district, *M. laevigata*.

pollinated seed that exhibited high variability in stem characters (short internodal distance (2 cm), erect branches and high branching nature). The collections from Khatu area also exhibited more variation in stem characters.

Alwar

The exploration team surveyed several areas, namely Shilished, Narayana villas, Company Bhag and Sariska National Park. A total of three mulberry germplasm were collected. Company Bhag, popularly known as Purajan Vihar, was established in 1868 and has more than 75 old mulberry trees belonging to *M. laevigata* (AR200/21.9) and *M. alba*, which bears exclusively white fruits. The leaves of *M. laevigata* are rough and coriaceous in nature. Most of the trees are facing extreme drought condition. The survey team identified some trees with severe leaf scorching and sprouting was greatly affected as observed visually. The Sariska Tiger Reserve has a rich flora and fauna. However, there are many mulberry trees at Shilished near the National park on the mountain area side. The mulberry genetic resource (AR2002/1.8), which was collected near by the mountain area possess heterophyllous leaves, were 0- 4 lobed, smooth and with a thick coriaceous texture.

Fig. 3 Mulberry species complex from Rajasthan. (**A**) *M. alba* at Kumbhalgarh, (**B**) *M. laevigata* at Nathdwara, (**C**) *M. indica* at Khatholai, (**D**) *Morus* hybrid at Ramganjbalaji.

Fig. 4 Variation of flower and fruit collections from Rajasthan. (**A-B**) *M. indica*, (**C-D**) *M. laevigata*, (**E-F**) *M. alba* and monoecious (**G-H**) *M. indica* having both male and female and bisexual fruit.

Shri Ganganagar

The Shri Ganganagar area, adjacent to Punjab, is the most potential area with respect to agriculture and also the availability of *Morus* species. A total of eight mulberry genetic resources were collected in this district. The *M. laevigata* collections (AR-20021-17, 18) are characterized by thick coriaceous, lobed leaves (0-10 lobed) bearing white, long (10-12 cm) and sweet fruits. The Central State Farms at Jaitsar and Suratgarh (largest mechanized farm in

Asia) have been extensively surveyed and a large number (25) of mulberry trees with a girth of 2.5-3.5 m were found.

Udaipur

Seven collections mainly belonging to *M. indica* grow in the wild. The leaves are mainly lobed with a mixed phyllotaxy with a smooth to rough surface and charataceous texture. The sex expression is mostly female with black fruits. The *M. indica* collections growing wildly in the hilly regions of Jhadol (Udaipur district) have a distinct morphotype and the mulberry leaf is used as cattle feed.

Sirohi

Two collections from Mount Abu were made of which *M. indica* collection is promising with good quality of leaves for silkworm feeding. The leaf surface is very smooth, succulent and glossy. The leaves are heterophyllous and lobed. The sex expression is monoecious with all types of catkins viz. male, female and bisexual which can be used in different mulberry breeding programmes as either of the parent. The fruit is black and sweet in taste. The *M. laevigata* collection is coriaceous with broad, ovate, and rough surfaced leaves. The sex expression is female with long catkins (10-15 cm). The concerted efforts of raising a tree plantation of these local landraces in the Peace Park at Mount Abu reflect an example of on-farm conservation. The collections from Posaliyan, Utaman, and Malpura also belong to both *M. indica* and *M. laevigata*. The *M. laevigata* collections are very old and both are homophyllous. The collection at Manduva is highly lobed (6-7), half phyllotaxy, rough, coriaceous and greenish-white long (12 cm) sweet fruits. The collection from Sirohi (Bhimaji garden) is homophyllous, unlobed, smooth, and coriaceous with pinkish-white sweet fruits. The collections from Utaman and Posalia mainly belong to *M. indica* with heterophyllous lobed (0-1 lobed) with purplish-black fruits. The Posalia collections are mostly monoecious in nature.

Jodhpur

Four collections from Jodhpur district mainly belong to *M. indica* growing in arid conditions at the Central Arid Zone Research Institute (CAZRI) and the National Bureau of Plant Genetic Resources (NBPGR) regional stations. These accessions are also being maintained in the NBPGR regional station. The leaves are very small in size and mainly unlobed with mixed phyllotaxy. The leaf surface is smooth to rough with a charataceous texture. The sex expression is mostly female with black fruits; some pure male plants have also been collected. The trees attained 10 years of age. These accessions have also been maintained in the nursery of REC, Central Silk Board, and Fathenagar of Rajasthan as a backup conservation. The Mandore collections at Balasamand belong to *M. laevigata* with 2 lobes, wide ovate shape and coriaceous texture. The sex is female with pale yellow sweet fruits.

Ajmer

Two collections belong to *M. indica* and *M. laevigata* cultivated for horticultural purposes in many areas of Puskar. The *M. indica* variety is also used as a root stock for bud grafting of *M. laevigata* for plantation on a large scale. Both these varieties are female and the fruit is black and creamish green in *M. indica* and *M. laevigata* respectively.

Kota

The district of Kota is considered to be the most fertile area in Rajasthan with much agricultural production. There are three local varieties cultivated exclusively for sericulture. The *M. laevigata* collection at Nagbagh is predominantly female with white creamish coloured sweet fruits. The leaves are wide ovate and rough.

Bundi

Three varieties belong to both *M. indica* and *M. laevigata* were collected from Bundi district. The local collections of *M. indica* at Mangli river side, Ramganjbalaji are very promising with smooth leaves (**Fig. 3**). A population of 12 trees was noticed with luxuriant growth. The leaves are charataceous in nature and used mostly for fodder.

Pali

Four collections from the district Pali belong *to M. indica* are mainly female with black coloured sweet fruits. The leaves are mostly unlobed homophyllous in nature and rarely one lobed. The leaves are smooth with a charataceous texture. One collection from Posalia (AR-2008.1-8) is promising with 0-1 lobed leaves with monoecious sex expression.

Jalor

Four mulberry germplasm were collected, two being *M. laevigata* and two being *M. indica.* The *M. laevigata* collections were both lobed (4-lobed) and unlobed, females with greenish sweet fruits. The *M. indica* collections were male, heterophyllous, lobed (0-1) and female, homophyllous, unlobed. The Malpura farm has a cluster of trees belonging to *M. indica*. The leaves are used as cattle feed.

Barmer

The Barmer district was surveyed for its vegetation pattern. A typical desert-type of vegetation was noticed. The arid zone with poor rainfall does not support broad-leaved plants. The distribution of mulberry both under natural and managed habitats is very scanty. The survey team located two collections in Samdari. The *M. indica* collection is promising with erect branching nature. The leaf surface is slightly rough with 0-4 lobes. The leaf lobation is heterophyllous but mostly unlobed, half phyllotaxy, acuminate leaf apex, serrate margin and the base is mostly truncate but slightly cordate. The sex expression is female. The fruit is black and sour. In Manoranjan Sadan, Samdari, a single *M. laevigata* tree was observed. The leaves are highly coriaceous, broad and ovate, rough surface with 6-7 lobes. The sex expression is female with long catkins (8.5-10 cm).

Jaisalmer

The desert national park and adjoining areas were surveyed for mulberry germplasm and other forest species. The region has a great diversity in vegetation. The natural distribution of mulberry and other broad-leaved plant species was not observed in the region. The desert plant species support the livelihood of farmers and local tribals mainly for fodder and fuel. Introduction of promising drought-tolerant plant species including mulberry in this area is the priority activity of social forestry. One local collection of *M. indica* was located which is growing under extreme drought conditions. The tree was small and about 5 years old. The lobation was 1-2-lobed with 2/5 phyllotaxy. The leaf apex is short and acuminate, the base is cordate and the margin is fine serrate. The tree is dioecious female with black, sour fruits. The style is medium to long (0.8-1.5 mm).

Bikaner

The collections from Bikaner belong to both *M. indica* and *M. laevigata.* The survey team located a large collection of mulberry trees of both species at the farm area of Rajasthan Armed Constables (RAC), Bikaner. The trees are propagated as mixed farming for the fruits and leaves for cattle feed. The collections are mostly dioecious female with

homophyllous, unlobed and half phyllotaxy. The fruits are very sweet.

Table 2 Variability of mulberry accessions collected from Rajasthan on growth and yield attributing parameters characters.

Accession Number	No. of shoots	Length of longest shoot (cm)	Total shoot length (cm)	Lamina length (cm)	Lamina width (cm)	Total shoot weight (kg)	Total leaf yield (kg)	Inter nodal distance (cm)	Weight of 100 leaves (g)	Total moisture content (%)	Moisture retention capacity (%)	Total biomass (kg)	Leaf shoot ratio	Laminar index
	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
MI-0674	42.83	173.83	5535.17	15.58	10.35	2.16	3.03	5.08	194.06	71.09	68.87	5.19	1.44	89.88
MI-0675	39.67	174.00	5166.17	15.58	9.50	2.49	2.76	4.25	128.88	68.74	52.71	5.25	1.12	90.36
MI-0676	24.17	172.67	3232.67	20.28	15.75	2.15	2.93	6.92	332.84	69.79	69.48	5.08	1.40	94.38
MI-0677	37.83	197.00	5434.83	14.77	12.28	2.43	2.24	5.33	206.67	69.47	59.43	4.66	0.93	89.96
MI-0678	52.67	200.83	7108.00	15.42	11.60	3.01	2.83	5.35	135.99	68.97	70.59	5.84	0.96	90.07
MI-0679	38.50	196.67	5513.83	18.22	13.28	3.18	3.58	5.39	230.81	74.03	67.20	6.75	1.16	92.71
MI-0680	42.83	203.17	5734.50	21.08	15.00	3.01	3.98	7.20	370.67	71.97	74.35	6.98	1.36	94.13
MI-0681	42.83	189.33	5879.33	13.97	11.63	3.06	3.34	5.30	142.49	70.23	58.23	6.40	1.10	90.09
MI-0682	30.67	202.67	4696.83	15.80	11.37	2.93	2.57	4.80	124.98	69.09	50.87	5.49	0.88	91.36
MI-0683	27.00	128.00	2516.17	13.38	10.38	0.77	1.02	4.73	117.89	71.34	57.61	1.78	1.40	83.65
MI-0685	21.00	151.17	2415.50	14.50	11.15	1.01	1.18	3.84	113.30	68.58	43.94	2.20	1.22	90.11
MI-0686	21.17	157.83	2458.33	16.53	11.38	1.22	1.78	3.61	225.09	73.10	56.24	3.01	1.48	89.14
MI-0687	28.00	193.33	3452.17	20.75	14.13	1.22	2.18	7.30	340.42	71.79	71.75	3.40	2.03	92.49
MI-0688	15.83	140.50	1740.50	19.78	18.17	1.23	2.18	6.81	420.99	72.79	58.53	3.41	1.81	93.83
MI-0689	22.00	144.17	2279.50	20.90	19.47	0.94	1.88	8.07	402.13	70.90	62.21	2.82	2.06	94.38
MI-0693	15.00	140.67	1555.83	22.75	21.75	0.71	1.48	7.70	518.31	72.39	70.38	2.18	2.12	95.22
MI-0694	18.17	148.50	2082.17	12.87	9.90	0.64	0.78	4.74	116.08	69.22	59.49	1.42	1.28	87.10
MI-0695	56.67	160.00	6817.00	12.23	9.98	1.98	1.83	4.45	89.80	71.19	46.83	3.81	0.93	87.44
MI-0696	13.67	105.00	1156.83	17.17	13.08	0.34	0.71	5.25	153.63	73.24	77.00	1.05	2.25	92.64
MI-0697	26.67	174.33	3280.83	14.47	10.92	1.05	1.26	4.77	144.11	70.94	58.33	2.31	1.22	89.92
MI-0698	23.83	165.50	2888.17	20.72	18.33	1.56	2.66	7.26	440.52	71.61	60.78	4.22	1.72	94.47
MI-0699	16.83	131.17	1427.50	9.62	8.18	0.43	0.61	4.28	93.29	68.73	55.87	1.03	1.44	85.37
MI-0700	12.00	100.50	824.17	17.22	15.82	0.30	0.79	6.78	508.39	72.49	58.33	1.09	2.66	92.37
MI-0701	14.50	101.17	1059.17	12.33	9.13	0.30	0.65	4.01	132.85	73.11	51.42	0.94	2.34	83.72
MI-0731	18.67	154.83	1872.33	19.67	15.58	1.08	1.92	6.87	610.42	67.74	76.79	3.00	1.82	93.60
MI-0732	18.67	60.58	1544.50	19.33	14.83	0.91	1.66	5.18	486.02	67.82	71.77	2.58	1.87	92.63
MI-0733	14.83	88.17	1082.17	11.00	9.84	0.24	0.45	4.40	150.74	69.94	62.41	0.69	2.04	84.54
MI-0734	15.17	96.67	1263.33	15.83	12.08	0.43	0.74	4.99	340.43	62.78	62.25	1.17	1.74	91.37
MI-0735	12.17	61.83	544.83	13.95	12.45	0.19	0.67	5.99	460.97	65.15	66.46	0.87	4.18	89.52
MI-0736	11.33	58.17	474.83	16.67	12.50	0.20	0.49	3.81	215.35	70.48	50.14	0.69	2.62	90.20
MI-0737	10.83	47.33	391.17	12.00	11.33	0.16	0.24	3.19	292.37	71.70	68.55	0.40	1.64	88.81
MI-0738	17.00	104.17	1372.50	16.25	12.83	0.55	1.23	4.73	392.36	66.05	64.25	1.78	2.37	91.75
MI-0739	17.17	79.33	991.50	11.80	9.17	0.35	0.62	3.46	161.15	67.96	57.57	0.97	1.75	85.80
MI-0740	19.83	114.17	1562.83	18.00	17.33	0.98	2.11	6.87	763.77	68.10	62.11	3.10	2.20	93.56
Mean	24.71	138.74	2804.56	16.19	12.96	1.27	1.72	5.37	281.11	70.07	61.85	2.99	1.72	90.49
Min	10.83	47.33	391.17	9.62	8.18	0.16	0.24	3.19	89.80	62.78	43.94	0.40	0.88	83.65
Max	56.67	203.17	7108.00	22.75	21.75	3.18	3.98	8.07	763.77	74.03	77.00	6.98	4.18	95.22
SD	12.38	46.73	1991.10	3.34	3.27	0.99	1.02	1.34	171.16	2.47	8.39	1.97	0.66	3.22
SE	2.16	8.14	346.61	0.58	0.57	0.17	0.18	0.23	29.80	0.43	1.46	0.34	0.12	0.56
CV%	50.12	33.68	71.00	20.62	25.22	77.74	59.35	24.96	60.89	3.53	13.57	65.87	38.36	3.55

Table 3 Analysis of variance (ANOVA) for growth parameters of Rajasthan collections.

Source of variation	DF	No of shoots	Length of longest shoot (cm)	Total shoot length (cm)	Leaf length (cm)	Leaf breadth (cm)	Total shoot weight (kg)	Total leaf yield (kg)
Mean sum of squares (MSS)								
Acc	33	920.122*	13102.683***	23786806.000***	66.849467***	64.067003***	5.851***	6.224***
Error(A)	165	52.856	410.344	841702.5	3.6854402	2.270871	0.206	0.278
Total	203	206.13	2466.427	4674401.5	13.956965	12.443792	1.127	1.246
Source of variation	**DF**	**Internodal distance (cm)**	**Weight of 100 leaves (g)**	**Total moisture content (%)**	**Moisture retention capacity (%)**	**Total biomass (kg)**	**Leaf: shoot ratio**	**Laminar index**
Mean sum of squares (MSS)								
Acc	33	10.792	33	175774.969***	36.633***	422.563***	23.218***	2.615***
Error(A)	165	0.739	165	4213.3	13.744	37.953	0.886	0.302
Total	203	2.363	203	32118.813	17.164	101.007	4.526	0.676

Evaluation of Rajasthan collections for growth attributing and leaf histological parameters

The growth data (**Table 2**) revealed wide variability for different growth traits. All the Rajasthan collections exhibited higher variation for the leaf characters such as 100- leaf weight, leaf yield and leaf shoot ratio and for shoot characters such as number of shoots/plant, length of longest shoot, total shoot length, total shoot weight, total biomass and internodal distance. The CV % was high (> 50 %) for number of shoots, total shoot length, total shoot weight, 100 leaf weight, leaf yield and total biomass. The leaf variability of Rajasthan collections varied from unlobed to multilobed (**Fig. 2**). The ANOVA on different growth attributes exhibited significant variation among the accessions (**Table 3**). The variability of leaf histological parameters in the Rajasthan collections is presented in **Table 4**. The ANOVA on leaf histological parameters, presented in **Table 5**, showed significant variation. Stomatal characters and their relation in drought tolerance were reported by many authors (Leveit 1972; Susheelamma and Datta 1995). The succulence of a mulberry leaf is dependent on the palisade and spongy mesophyll thickness. In the present study mean number of chloroplast mostly ranged from 8.22-12.89 which are mainly considered as diploids except two accessions namely MI-0700 (15.56) and MI-0740 (13.78) which may be polyploids. Number of chloroplasts/guard cell of the stomata are directly correlated to the ploidy status (mean chloroplast number/stomata in diploids - 10.84, triploids - 14.22 and tetraploids - 17.27) of the mulberry accessions (Yang and Yang 1995; Tikader *et al*. 1999; Tikader and Ananda Rao 2001; Ananda Rao *et al*. 2003). However, confirmatory tests have to done through cytological studies and karyotype analysis. The frequency of idioblasts and cystoliths with their calcium deposits deteriorates the palatability of mulberry leaves for silkworms (Cappellozza *et al*. 1998). The cuticle and epidermal layers not only protect the mulberry leaves from dehydration, but also act as a barrier for the entry of pathogenic microbes and pests. Collections from Rajasthan exhibited significant variation in reproductive characters (sex expression, stigma and style length, size and colour of fruits) and most leaf histological characters

Table 4 Variability of mulberry accessions collected from Rajasthan on leaf histological parameters.

Accession No.	Stomatal size (μm^2)	Stomatal frequency/ mm^2	Chloroplast number /stomata	Idioblast length (µm)	Idioblast diameter (µm)	Idioblast frequency / mm^2	Cystolyth length (µm)	Cystolyth breadth (µm)	Upper cuticle thickness (µm)	Lower cuticle thickness (µm)	Upper epidermal thickness (µm)	Lower epidermal thickness (µm)	Palisade parenchyma thickness µm)	Spongy parenchyma thickness (µm)	Total leaf thickness (µm)	P:S ratio
	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
MI-0674	243.84	804.19	10.22	8.43	24.90	21.27	67.43	47.51	6.71	3.93	32.18	20.31	73.18	70.11	206.41	1.11
MI-0675	325.97	570.79	9.78	6.13	22.99	26.22	70.88	70.88	8.81	3.83	23.37	11.49	69.35	75.48	192.33	0.92
MI-0676	213.99	487.60	8.98	13.03	21.07	21.91	101.91	95.78	9.20	3.35	33.33	7.66	86.59	93.49	233.62	0.93
MI-0677	203.79	998.31	9.56	9.20	17.62	27.02	96.17	85.06	8.62	3.26	34.10	9.20	68.96	70.11	178.92	1.00
MI-0678	251.23	620.48	10.22	7.66	13.79	21.91	73.18	72.80	6.71	3.07	31.03	7.28	47.89	57.09	153.06	0.84
MI-0679	258.89	1041.06	8.89	13.03	19.54	20.23	107.28	105.75	6.13	3.35	31.42	12.26	47.51	54.79	155.46	0.87
MI-0680	350.71	656.30	11.56	7.47	20.69	12.71	105.75	104.60	6.99	3.35	32.18	16.48	85.44	98.47	242.91	0.87
MI-0681	331.07	571.95	8.22	14.56	26.44	23.91	73.95	86.21	7.38	2.49	16.09	9.20	68.96	78.16	182.28	0.89
MI-0682	297.91	719.85	9.78	13.79	23.37	22.15	54.02	72.41	8.08	2.30	19.92	8.43	53.64	54.41	145.88	0.99
MI-0683	304.03	506.09	8.89	19.16	33.72	17.99	69.35	85.44	6.51	3.45	29.88	9.58	49.04	50.57	149.04	0.99
MI-0685	310.66	508.40	9.78	13.79	17.62	15.83	83.14	88.89	4.98	4.21	29.50	7.76	51.72	53.64	151.82	0.97
MI-0686	394.58	462.18	9.33	7.66	16.86	16.79	83.14	90.04	7.09	2.78	18.77	10.73	50.57	53.64	143.58	0.94
MI-0687	351.47	479.51	11.11	8.43	25.67	10.63	85.44	75.48	8.33	4.60	31.42	8.43	70.50	75.86	199.13	0.93
MI-0688	328.01	482.98	11.11	13.03	30.27	12.31	86.97	92.34	7.66	3.83	34.48	9.20	71.26	78.93	205.36	0.91
MI-0689	291.02	429.83	11.33	8.05	15.33	14.31	88.12	89.65	7.09	3.77	31.80	6.90	81.99	88.12	219.25	0.93
MI-0693	323.93	697.89	8.22	8.43	15.33	13.59	88.12	84.67	5.46	3.45	22.22	8.43	68.20	87.93	185.92	0.78
MI-0694	222.92	866.59	9.11	9.96	26.82	27.90	87.74	105.75	5.46	3.07	22.61	14.56	57.85	73.56	177.10	0.79
MI-0695	242.05	593.90	9.33	8.81	24.90	18.23	77.78	85.82	6.42	3.77	22.61	6.90	57.09	62.07	158.43	0.92
MI-0696	355.30	623.94	10.44	7.11	25.67	17.75	96.17	86.59	6.42	3.64	24.14	13.03	90.80	103.45	241.47	0.88
MI-0697	231.34	932.45	10.22	7.47	23.75	18.63	68.58	71.26	6.32	2.11	22.61	11.11	62.07	63.60	167.81	0.98
MI-0698	284.65	645.90	10.00	19.54	45.59	19.99	88.50	86.21	6.99	4.74	32.18	14.18	73.18	72.41	203.16	1.01
MI-0699	218.33	993.69	8.67	12.26	29.12	30.78	70.88	72.80	7.66	3.45	24.52	9.96	65.13	83.14	193.87	0.79
MI-0700	361.42	396.32	15.56	12.26	58.62	12.23	74.71	76.24	7.66	3.35	18.77	10.73	76.24	81.22	197.98	0.94
MI-0701	307.60	838.86	9.56	29.50	89.27	18.63	84.29	91.95	7.28	1.82	28.74	8.81	56.32	72.80	175.76	0.78
MI-0731	305.82	425.21	12.00	21.07	57.85	12.07	92.72	107.28	8.33	3.45	24.90	13.03	85.82	86.21	221.74	1.00
MI-0732	429.52	309.66	12.89	8.05	38.70	8.08	112.64	100.00	7.66	3.83	24.14	8.81	90.80	90.80	226.05	1.00
MI-0733	250.47	655.14	10.89	8.43	92.72	19.35	65.52	77.01	5.75	4.02	30.65	10.35	57.85	57.85	166.47	1.00
MI-0734	308.62	585.81	10.67	33.33	65.13	13.59	51.72	84.29	7.66	2.97	30.27	12.64	62.07	62.07	177.68	1.00
MI-0735	236.44	650.52	12.89	17.24	75.48	15.75	77.39	75.86	7.28	3.74	34.87	8.81	54.02	55.94	164.65	0.97
MI-0736	273.42	599.68	10.67	7.18	100.00	20.87	75.86	86.21	6.71	3.64	28.74	10.25	53.64	59.00	161.97	0.91
MI-0737	259.40	618.17	10.67	7.09	66.67	13.91	54.79	52.87	8.05	3.54	19.92	13.56	67.82	71.26	184.15	0.95
MI-0738	287.20	644.74	11.11	9.96	70.88	14.79	69.35	86.59	8.81	4.12	16.48	12.26	50.96	86.21	178.83	0.59
MI-0739	298.67	776.46	10.00	7.66	118.77	24.78	70.88	66.28	7.95	4.02	27.59	8.43	71.65	77.39	197.03	0.93
MI-0740	356.57	447.16	13.78	6.51	54.02	11.27	70.50	70.88	6.61	3.35	36.02	8.05	56.70	78.54	189.27	0.73
Mean	294.44	636.52	10.45	11.92	41.45	18.16	80.14	83.28	7.20	3.46	27.10	10.55	65.73	72.89	186.13	0.91
Min	203.79	309.66	8.22	6.13	13.79	8.08	51.72	47.51	4.98	1.82	16.09	6.90	47.51	50.57	143.58	0.59
Max	429.52	1041.06	15.56	33.33	118.77	30.78	112.64	107.28	9.20	4.74	36.02	20.31	90.80	103.45	242.91	1.11
SD	54.25	182.58	1.59	6.37	28.22	5.47	14.91	13.82	1.03	0.64	5.72	2.95	12.91	14.20	27.55	0.10
SE	9.44	31.78	0.28	1.11	4.91	0.95	2.60	2.41	0.18	0.11	1.00	0.51	2.25	2.47	4.80	0.02
CV%	18.42	28.68	15.18	53.40	68.10	30.11	18.60	16.60	14.27	18.47	21.10	27.91	19.64	19.48	14.80	10.97

Table 5 Analysis of variance (ANOVA) for leaf histological parameters of Rajasthan collections

Variables	df	Stomatal size (μm^2)	Stomatal frequency/ mm^2	Chloroplast number/ stomata	Idioblast length (µm)	Idioblast diameter (µm)	Idioblast frequency/ mm^2	Cystolyth length (µm)	Cystolyth breadth (µm)
Mean sum of squares (MSS)									
Acc	33	26482.904***	300009.844***	22.646***	365.957**	7169.476***	268.961**	1999.571**	1718.967***
Error(A)	264	1357.391	1640.145	3.062	6.807	45.604	2.14	22.161	40.117
Total	305	4069.905	33896.05	5.16	45.655	815.383	31.049	235..934	222.094
Variables	**df**	**Upper cuticle thickness (µm)**	**Lower cuticle thickness (µm)**	**Upper epidermal thickness (µm)**	**Lower epidermal thickness (µm)**	**Palisade parenchyma thickness (µm)**	**Spongy parenchyma thickness (µm)**	**Total leaf thickness (µm)**	**P:S ratio**
Mean sum of squares (MSS)									
Acc	33	9.285***	3.320***	294.362***	78.039**	1535.539**	1760.400**	6830.236*	0.090***
Error(A)	264	1.265	0.377	7.652	3.447	42.36	46.952	116.867	0.009
Total	305	2.151	0.701	38.632	11.566	204.335	231.567	844.038	0.018

(stomatal size, idioblast size and frequency, spongy mesophyll thickness, cuticle and epidermal thickness) due to the presence of many wild *Morus* species like *M. laevigata* and landraces (Dwivedi *et al*. 1989; Ananda Rao *et al*. 2000). A higher CV% was recorded for idioblast parameters. The promising mulberry accessions with leaf yield >3 kg in MI-0674 (Kakad), MI-0679 (Durgapur), MI-680 (Kota) and MI-0681 (Kota); total biomass > 6 kg/plant in MI-0679, MI-0680 and MI-0681; Moisture content 74.03% in MI-0679; moisture retention capacity > 74% in MI-0680, MI-0696 (Mandore) and MI-0731 (Puskar); stomatal size 203.79-213.99/μm^2 in MI-0677 (Durgapur) and MI-0676 (Durgapur)]; stomatal frequency 396.32/mm^2 in MI-0700 (Durgapur)]; upper cuticle thickness 9.20 µm in MI-0676 (Durgapur) which may be utilized in breeding programmes for stress tolerance (**Table 3**).

Potential areas for mulberry germplasm resources

The villages Palsana, Ringus, Laxamangarh and Khatu (Sikar district) Kumbhalgarh, Nathdwara, Haldigati Oglat, Older and Vardada (Rajsamand district) and Jhadol, Kakad (Udaipur district) are potential areas for the availability of different local landraces of *Morus* species and from which a total of 18 landraces were collected. The *M. indica* landraces are more popular and widely distributed in the village areas cultivated for the purpose of shade and these varieties are propagated through plantation of stem cuttings. The Palsana Government Horticulture Nursery (Nutritional Garden) is raising mulberry saplings and selling them to the farmers while the fruits are being sold on the market. One collection (AR2002/1.15) from Palsana derived from open pollinated seed and exhibited high variability of stem characters (short internodal distance, erect branches and high branching nature). The Shri Ganganagar area, which is adjacent to Punjab, is also a potential area for agriculture and also the availability of *Morus* species. A total of eight mulberry genetic resources were collected in this district. The *M. laevigata* collections are characterized by thick coriaceous, lobed leaves (0-10 lobed), female bearing white, long and sweet fruits. *M. laevigata* is cultivated for horticultural purposes in many areas of Puskar. As the rooting is very poor in these varieties they are propagated mainly through bud grafting to the local landrace belong to *M. indica* which is used as a root stock for plantation of *M. laevigata* collections in large scale in the region. The efforts of Rajasthan Armed Constables (RAC), Bikaner and Govt. UP. School, Bithiya, Jalore in raising and propagating mulberry varieties (particularly *M. indica* and *M. laevigata*) is an example of on-farm conservation of these species under managed habitats.

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