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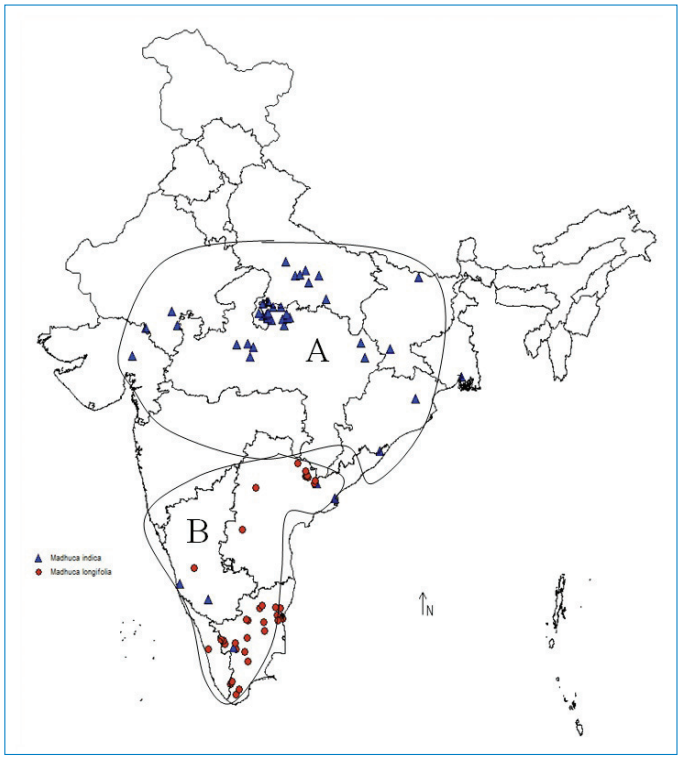
Traditional importance of Indian butter tree and genetic resources management

Madhuca longifolia **(Koenig) Macbr. (syn. *M. indica* Hamilton ex Gmet.) locally known as Mahua is an important tropical tree species having vital socio-economic value for the tribal populations of India. Vast genetic diversity of this species exists in tropical and sub-tropical parts of India. During various surveys, a total of 154 accessions were collected from different phyto-geographical regions. Substantial variability was present in collections made from west-central region especially from the states of Rajasthan, Gujarat, Madhya Pradesh and Uttar Pradesh and from southern states of Andhra Pradesh and Tamil Nadu. It is a multipurpose tree providing food, fuel, timber, green manure, oil, liquor and raw materials for several commercial products. In spite of its high economic value there are no improved cultivars or varieties developed in Mahua, however, some selections based on physico-chemical characters, period of fruit maturity and high seed oil content have been identified. Due to direct harvesting of economically important parts of this tree from natural habitat and deforestation, genetic diversity of Mahua is facing threat of extinction and requires immediate conservation efforts. Limited success achieved in cryopreservation of embryonic axes of this highly recalcitrant tropical tree species necessitates further refinement of protocol and also implementation of complimentary conservation strategy by maintaining field genebank collections of promising genotypes. Urgent attention is also required for popularization and needful value addition to the commercial products of Mahua to attract present day market demand.**

MADHUCA longifolia (Koenig) Macbr. (syn. *M. indica* Hamilton ex Gmet.) (syn. *M. latifolia* Macb.; *Bassia latifolia* Roxb.), family Sapotaceae, is an important tree having vital socio-economic value for tribal populations of several Central Indian States. *Madhuca* probably originated in Indo-China region and spread up to Australia. Its vernacular names are region specific; however, most commonly used name is Mahua. In India it is found largely in semi-deciduous dry forests of Western, Central and Southern India mainly in Andhra Pradesh, Bihar, Chhattisgarh, Gujarat, Jharkhand, Madhya Pradesh, Maharashtra, Rajasthan and Uttar Pradesh. It is a multipurpose tree providing food, fuel, timber, green manure, oil, oil cake, liquor and raw materials for several products. It is a fast-growing tree reaching approximately 20 m in height and possesses evergreen or semi-evergreen foliage with wide and round canopy. The succulent cream-coloured corollas fallen on the ground during March and April are collected and dried. These are a rich source of sugars and contain appreciable amounts of vitamins and calcium. Production of liquor from Mahua flower is a traditional practice for centuries. Seed oil is locally used for the care of skin, for manufacturing of soap and detergents and also as a vegetable butter. The seed cakes obtained after extraction of oil is used as a very good fertilizer. It is one of the most valued trees among tribal communities of central India and its every part is used for various purposes. Trees of Mahua are retained and preserved in the farmer's field and marginal lands due to its socio-economical importance. Therefore, large numbers of trees exist in the villages, road sides as social forestry tree and on Panchayat lands besides large populations in the tropical forests. There are no systematic studies undertaken on genetic resource management of this species in India. Collection of germplasm, characterization and evaluation for elite genotypes and conservation of existing genetic diversity using *in situ* and *ex situ* conservation are some of the important aspects in the genetic resource management of this species. Mahua seeds have been reported to have a very short storage life of 20 days after harvest, when viability is lost completely. Maximum longevity of 30 days is reported when fresh seeds are stored at 15°C temperature. True recalcitrant seed storage behaviour of Mahua seeds has been confirmed.



Diversity collected from different phyto-geographical regions of India in *Madhuca*. (A). Diversity distribution of *Madhuca longifolia*. (B). Diversity distribution of *M. longifolia* var. *latifolia*.

The seeds are shed at high moisture content (above 50%) with high viability of 90-100% and are desiccation sensitive. The present paper highlights the assessment of genetic diversity in Mahua and its distribution in India along with plant genetic resources management, its socio-economic importance and scope for marketability of its products.

Survey and exploration trips were undertaken to diversity-rich areas of Rajasthan, Gujarat, Madhya Pradesh, Chhattisgarh and Uttar Pradesh for the systematic localization of various populations and collection of Mahua germplasm from the natural populations. Collections were made using selective sampling strategy and each collection was allotted a National Identity (accession number-IC) and detailed passport information was recorded in the prescribed format developed by NBPGR. A total of 29 accessions were collected in the form of fruits from Rajasthan and Madhya Pradesh. Passport data and all the related information was recorded in the NBPGR data base for the collected germplasm. Detailed information about indigenous traditional knowledge regarding the use of various plant parts, socio-economic value and livelihood contribution of this important multipurpose tree species was collected from the elderly persons of tribal communities and other local inhabitants of the forest and marginal areas. Information about present status of genetic variability, population structure, market value and support system was gathered during the survey of field, local markets and weekly markets (Hats). Information on present status of tree count in a population viz past status during last 2-3 decades was also obtained to assess any changes in the population size of this species over the years. Discussions were held with the tribal farmers, forest officials and other local inhabitants to have their input on the value addition prospects, market support system and policy issues related to conservation and sustainable utilization of this important multi-purpose tree species. Embryonic axes excised from the fresh seeds were desiccated to various moisture contents in the laminar air flow by exposing to sterile air for various periods. Moisture content of embryonic axes was recorded after each hour of desiccation using low constant temperature method of 17 h drying at 103±2°C temperature. Viability testing of embryonic axes fresh, desiccated, before and after cryopreservation was tested using *in vitro* method on Murashige and Skoog's medium supplemented with $1gl^{-1}$ activated charcoal, $0.17\ gl^{-1}$ NaH_2PO_4, $1mgl^{-1}$ each of 6-Benzylaminopurine (BAP) and Naphthalene acetic acid (NAA). Cultures were kept in the dark for two weeks before shifting to the culture room maintained at 25 ± 2°C with a 16 h photoperiod under light intensity of 35 $\mu Em^{-2}\ s^{-1}$. Growth of embryonic axes was observed after various periods and data on root and shoot regeneration was recorded. Data recorded after 60 days of embryonic axes culture has been presented in the Table 1.

Taxonomy and nomenclature

Madhuca longifolia (Koenig) Macbr. (syn. *M. indica* Hamilton ex Gmet.) (syn. *M. latifolia* Macb.; *Bassia latifolia* Roxb.)

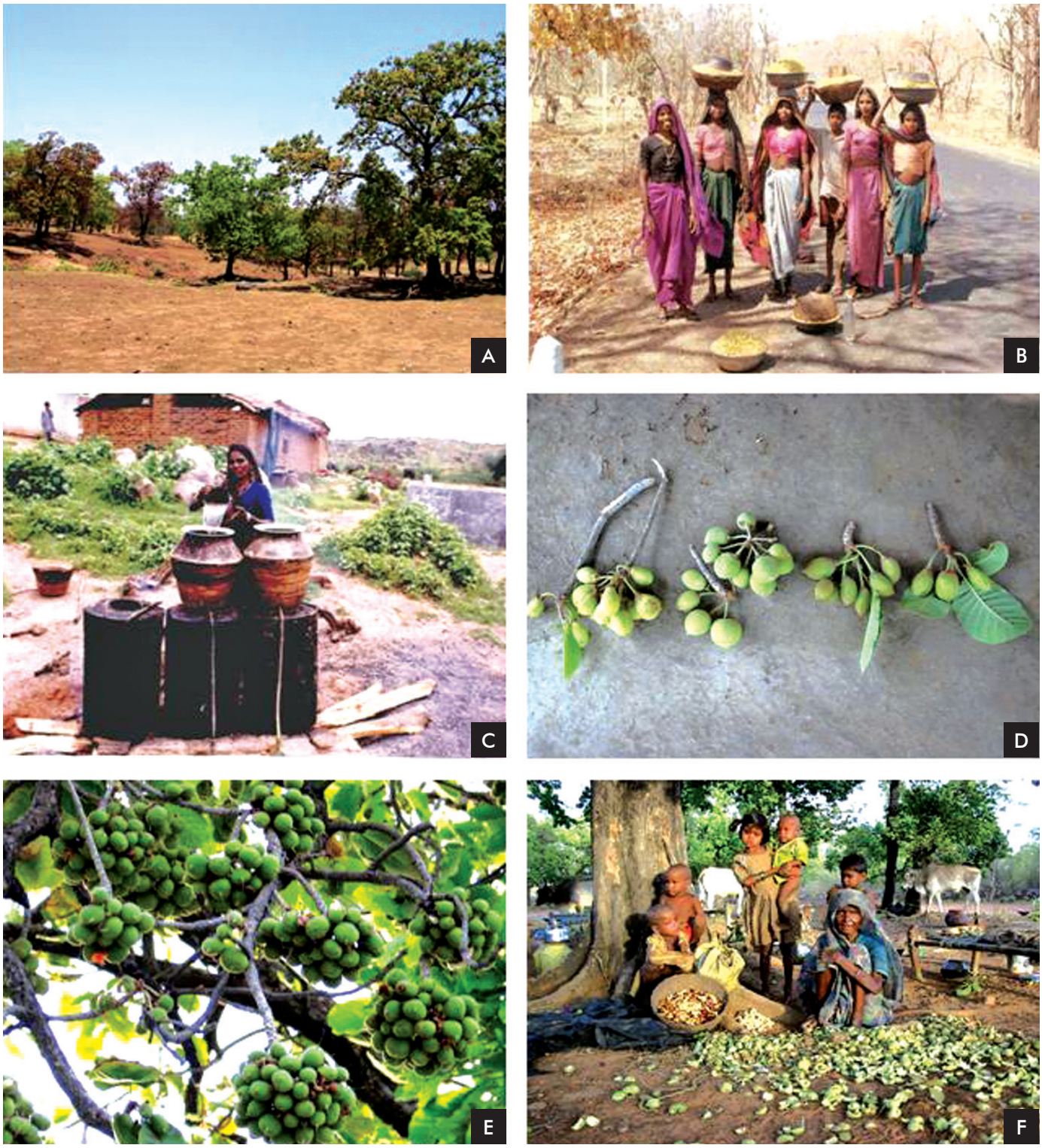
Synonym(s): *Madhuca latifolia* Macb., *Bassia latifolia* Roxb., *Mahua indica* J.F. Gmel.

Bassia latifolia Roxb. Cor.Pl. t. 19 ; Fl. Ind. Ii 526 ; Bedd. Fl. Sylv. T 41, - Sans. *Madhuka*.

Region specific vernacular names: Bengali (Mahl and Mohwa), Gujarati (Mohuda, Mahude and Mavd), Hindi (Mahua, Mohwa and Maul), Kannada (Ippahal, Tumbri, Hippa and Honge), Malayalam (Illupa), Marathi (Moho, Mohwa and Mohwra), Oriya (Modgi, Mahula and Moha), Punjabi (Mohwa), Tamil (Illuppai, Elupa and Kat-illipi), Telugu (Ippa, Ippi and Yeppa), English (Butter tree), and Trade name (Mahua).

Plant description

M. longifolia is a medium to large size deciduous (occasionally shedding leaves), fast growing tree 20 m height. It has a large spreading root system. Wood is hard to very hard with large sap wood. Hardwood is reddish to brown in colour. Tree possesses evergreen or semi-evergreen leaves which cluster near ends of branches, elliptic or elliptic-oblong, pubescent and turn to glabrous at maturity. Young leaves are pinkish red and woolly underneath. Flowers white to cream colour with tubular, fleshy and juicy corolla, clustered at the end of branches. Fruits ovoid berry, green at maturity and turn pinkish yellow when ripe. Fruits are pulpy with large ovoid seeds, number of seeds per fruit varies from 1 to 4. Fruits occur single or in a bunch up to 20-30 in one bunch. Seed is large, 3-4 cm long, elliptical, flattened on one side, seed light brown to black in colour. Most of the leaves fall between February to April and at the same time musky-



Survey, collection, variability and uses of *Madhuca longifolia* (Mahua) fruits and flowers: (A) Natural wild population of Mahua in Gujarat; (B) Flowers being collected in early morning by tribal women; (C) Preparation of Mahua liquor using traditional methods from Mahua flowers by tribals of Madhya Pradesh; (D) Fruit variability collected from Madhya Pradesh; (E) Prolific bearing in heavy bunches of 25-35 fruits in genotype collected from Rajasthan; (F) Seed extraction from fruits by tribals for oil extraction.

scented flowering commences. Fruits mature generally in the months of May-June. Tree blooms at night and in early morning hours flowers fall on the ground and are collected by local tribal populations for commercial use. In southern parts of India *Madhuca longifolia* var. *latifolia* occurs which is similar in the tree morphology to *M. longifolia*, with a exception in the shape of leaves which is linear lanceolate in *M. longifolia* var. *latifolia* and also flowering period varying between November-December.

Ecology, diversity and distribution

M. longifolia is predominantly distributed in northern and central states of India while *M. longifolia* var. *latifolia* is more common in southern states of India. Mahua grows

well on a wide range of soils especially on alluvial soil in Indo-gangetic plain. Mahua being hardy tree, thrives well on rocky, gravelly red soils and also on saline and sodic soils. Tree prefers tropical to sub-tropical climate and withstands drought admirably. It grows upto an altitude of 1,200 m, mean annual temperature 2-46°C and mean annual rainfall ranging from 550-1,500 mm. Some of the *Madhuca* species grow in Western Ghats and also found in Himalayan regions upto an altitude of 4,500 m.

Uses and indigenous technical knowledge

Every part of Mahua tree is used for economical and medicinal purposes by the local and tribal people. Their livelihood is based on the various tree parts and range of products developed from these which are collected directly from the forests and sold in local markets. Flowers of Mahua are of high economic value and collected fresh in the morning by tribal women. Mostly the dried flowers are used for distillation of Mahua liquor locally known as "Mahudi" which is a very common alcoholic drink in the tribal areas. For making liquor, flowers are fermented in the large sized earthen pots for months and fermented extract is distilled in locally developed distillation units known as "Bhattis". Liquor is collected in small earthen pots for selling it to local people. Mahua flowers yield approximately 340 litres of alcohol per tonne of flowers.

Marketing potential of its flowers, fruits, seeds, wood and other products have not been realized fully by industry. Till now tribals and local inhabitants are collecting the produce and either utilizing for traditional preparations or selling these to middleman. For seed oil extraction local middlemen purchase the dehulled kernels from villagers and supply to wholesale markets for use in small expellers.

Propagation

Mahua can be propagated by seeds and by vegetative means. While propagating through seeds, germination of seeds may immediately be attempted after depulping the mature fruits. Seeds are highly recalcitrant and also showed precautious germination when seeds remained in the fruit. Vegetative propagation methods have been developed using soft wood grafting, wedge grafting, veneer grafting and air layering with varying success.

Characterization

Mahua germplasm collected from various states have been characterized for different physico-chemical characters and field performance on the basis of early, mid and late season types. Variations in TSS, acidity, vitamin C and vitamin A in fruits and flowers have been reported. Genetic divergence were studied in 15 Mahua genotypes and MH-23, MH-26, MH-27, MH-32, MH-33, MH-34 and MH-35 and collections were reported to be promising in all the traits analyzed. Based on characterization of 20 accessions collected from Gujarat, MH-10, MH-14, MH-35 and MH-63 have been found promising for all the traits.

Conservation

Trees of Mahua were found to be growing as natural wild in the forest, marginal lands, farmers' fields and as an avenue tree throughout the Indian plains. Due to the very high socio-economic importance of this tree species for tribal populations living in the forest areas and around the protected forests, its importance as livelihood support species is immense. These trees are also treated as sacred in some parts of the country, therefore, protected by tribal people and state forest departments. However, due to the large scale developmental projects, urbanization and demand of land for agriculture some of the promising populations of this highly diverse tree species have been wiped off completely and some are under great threat. *In situ* conservation of Mahua in forests and marginal lands needs to be ensured to protect the existing genetic diversity. Awareness regarding conservation of plants and equal participation of tribal farmers in such activities is imminent as for the collection of produce (flowers, bark and fruits) whole tree is damaged by cutting the main branches. Promising populations in the states of Madhya Pradesh, Gujarat, Rajasthan, Uttar Pradesh, and other states need to be protected as *in situ* conservation sites. Recently, some of the promising accessions are being established in the field genebanks at CHES, Central Institute of Arid Horticulture, Godhra (Gujarat) and at Central Institute of Sub-tropical Horticulture, Lucknow, Uttar Pradesh. Such efforts need greater attention and priority of institutions to protect the promising genotypes of this important tree species.

Mahua is essentially a forest crop till now with no organized cultivation by farmers. Genetic resources of this tree species have not received much attention due to limited awareness towards its economic potential and being a tree of forest or marginal lands. As no organized commercial cultivation of Mahua is undertaken at present, there is not much demand for planting material and trees are naturally grown by seeds. Recently, vegetative means of softwood grafting with 70-80% success, grafting with 70% success and veneer grafting with 90% success has been reported.

Conservation of vast genetic diversity of Mahua needs use of both *in situ* and *ex situ* strategies. Mahua seeds have been reported as short lived, desiccation sensitive and highly recalcitrant in storage behaviour. Seeds were desiccation sensitive as at critical moisture content they showed decline in viability to 40%. Seeds desiccated to 37.7% moisture content lost germinability by 11% and those desiccated to between 14 to 16% moisture content lost germinability by 90% of the original. *Ex situ* conservation using cryopreservation of embryonic axes is an important alternative for this tropical tree species bearing highly recalcitrant and large seeds. It has been amply emphasized that cryopreservation is the only means currently available for long-term *ex situ* conservation of genetic diversity of recalcitrant seeded species.

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