Ethnobotanical Evidences *vis-à-vis* Domestication Trends in "Drumstick Tree" (*Moringa oleifera* Lam.) in India

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Drumstick tree (*Moringa oleifera* Lam.) has gained importance as potential species in view of its multipurpose usage, well adaptability to dry and hot climates of north-western plains, central India and drier regions of peninsular India. It has been protected as multipurpose tree species and domesticated as a vegetable in different parts of India. In the present communication, this species has been reported for ethnobotanical evidences on the basis of diversity distribution pattern in India and trends towards domestication.

Key Words: Domestication trends, Drumstick tree, Ethnobotanical evidences, Genetic resources, Multi-purpose species, *Moringa oleifera*, Protected species, Semi-domesticated species, Uses, Wild species

Introduction

Drumstick tree (*Moringa oleifera* Lam.) (family Moringaceae; commonly called horse radish tree, ben-oil tree, West Indian Ben) has recently gained importance as a multipurpose tree with tremendous potential uses in the tropical and subtropical regions. It is a fast-growing tree which is resistant/tolerant to drought and most pests. This species can be propagated sexually or asexually and can thrive in poor soil. In India it is propagated generally through cuttings (1-2 m long), preferably from June to August. This species occurs wild in the sub-Himalayan tracts of northern India from the river Chenab eastwards to the Sarda and in the tarai tract of Uttarakhand, foothills of Himachal Pradesh and part of northern Uttar Pradesh in India (Ramachandran *et al*., 1980; Joseph, 2007). The tree is widely cultivated and naturalized worldwide in the tropical and sub-tropical regions of the world (Morton, 1991).

The present day cultivated plants have been domesticated through the process of selection resulting in change of characters and bringing wild species under human management (Wilson, 1992; Diamond, 2002). Study of diversity distribution and ethnobotanical trends have provided evidences in understanding the process of selection for desirable traits. In *M. oleifera* information on ethnobotanical use as multipurpose species and a potential oilseed has pinpointed evidences in support of domestication (Jain, 1981; Jain *et al*., 1990; Samant and Dhar, 1997) in the protected/semi-domesticated areas in the tribal belt of India. In any case, the recorded information on its genetic resource value as potential species dates back to 400 years since its use for edible pods, seed oil, fodder and as medicine was known to the Indians (Watt, 1889). During the entire process, the cultivation must have resulted through series of selection from the wild types for desirable genotypes suitable for edible pods with more palatability (non-bitter forms), thus presenting a case of conscious folk domestication.

The published records have thrown light on the history of this little-known vegetable crop that was cultivated to a significant extent in south India. The earliest records (400 years old) of genetic resource use of *M. oleifera* are available in *Ain-i-Akbari* that lists the plant use as favourite pickles by the north Indians and as a commercial oilseed crop (Watt, 1889). This species was reported to be cultivated by the Dravidians (south Indians) in each and every home yard for exceptionally nutritious pods (Ramachandran *et al*., 1980). How this species moved from from centre of origin to other parts of the Indian region remains unclear (Fuller, 2006). During the past two centuries it was introduced to other parts of the world mainly as an ornamental and multipurpose species (Morton, 1991; Folkard and Southerland, 1996). Presently, this species is cultivated nearly throughout the Old World Tropics and also found naturalised in many regions of the world.

M. oleifera still largely remains a minor cultivated species in marginal land and small farm holdings as source of vegetable for domestic use and also sold in the local markets of India. Reasons for neglect in the past in northern

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India were probably the socio-economic preference and plant growth. But owing to rich nutritional content of fruit, leaf and other plant parts, it deserves renewed attention particularly for improvement and commercial utilization in India. The present investigation envisages the trends towards domestication on the basis of diversity distribution pattern, ethnobotanical evidences and changes in useful plant characters. Information on valuable plant genetic resources and their uses in India is also briefly discussed.

Materials and Methods

A total of 216 accessions of *M. oleifera* collected from different phytogeographical regions of the country during 1976-2010 were considered for present work. The germplasm accessions were classified into cultivated, protected/semi-domesticated and the wild types represented from diverse agro-climatic conditions. Selected samples (41) of cultivated and wild types were studied for agro-morphological/botanical characters viz., tree habit, branching pattern, leaf characters, flowering period, traits of flower (colour) and fruits (pod shape, size, ribs, colour), number of seeds/pod, seed characters (wings, colour, ease of detachment), seed coat hardness (soft/ hard), characters of seedlings, seed germination and oil contents. Observations were recorded using random samples (ten samples/per accession) of vegetative and reproductive parts. Comparison of morphological characters was done based on visual observations. Vouchers of herbarium specimen and seed samples (HS14244, 19907, 20281, 20282, 20285 and SS2893-2902) maintained in the National Herbarium of Cultivated Plants were used to validate the observations in present study. Analysis of information on diversity distribution pattern, ethnobotanical evidences and utilization of the species was done by the authors based on self-experience, non-formal interactions with local persons, farmers and experienced folks of the diversity regions and the published literature.

Result and Discussion

Botanical description

M. oleifera a deciduous perennial tree (height upto 12 m) is characterized by slender stem with brittle and corky bark, drooping branches and pale green and bi-tripinnate leaves. The flowers (2.5 cm diameter) are white-cream (rarely pink), honey scented, and borne in profuse axillary drooping panicles. The fruit (20-120 cm × 1.0-2.8 cm) is beaked capsule (also called pods), three valved, drooping, turns brown on maturity, nine-ribbed, angles are more prominent on maturity, splitting into three parts when dry; seeds (*ca* 15-24) with placentation parietal, creamish white-brown with three, embedded in pith, membranous and semi-deciduous wings. The seeds are orthodox, produced in large quantity and have no dormancy period and loose viability within a short period of 2-3 months. Under north and eastern parts of the country, leaves are shed in December-January and new ones appear in March-May along with flowers followed by fruiting. However, in the southern part of the country flowers and fruits are produced throughout the year, July to September and March to April being two peak periods (Wealth of India, 1962).

The wild and domesticated types exhibited very little botanical distinction except pod/seed characters. Study of population of both showed range of variation in tree stature (erect-spreading, moderately loose canopy), leaflet size, shape (round, obovate), flower colour (pink, creamish-white with base dotted/streaked with yellow), fruit bearing (cluster, sparsely bearing), fruit length (small-thin, long-thick), colour of pericarp (pale green, green, dark green), fruit surface (striated or smooth), fruit tip (red or green) and taste of pulp (bitter, tasteless). The wild types usually have bitter/semi-bitter, hard and fibrous poor quality fruits (Arora and Pandey, 1996).

Diversity distribution and ethnobotanical use

To domesticate a species there must be: (a) genetic diversity, (b) availability of useful plants/interesting types, and (c) reproductive isolation of the varieties selected. Thus, Indian gene centre offers great biodiversity with enormous number of useful plants for domestication (Arora, 1991). The tribal belts are more often considered as the centre of diversity and origin of many of these multipurpose species holding an array of potential plant diversity ranging from wild, semi-wild and domesticated forms (Maheshwari, 1986). The selection pressure operates through unconscious and conscious means through necessity-based, ritual-based or tribal customs/culture and socio-economy based requirements evolving desired types (Arora, 1981; 1997).

In the areas of natural distribution *M. oleifera* occurs as a component of the mixed broad leaved/conifer forest along forest of sub-Himalayan tracts, and river side of Uttarakhand and Uttar Pradesh, and central Himalaya (Strachey, 1974; Ramachandran *et al*., 1980; Gaur, 1999; Singh *et al*., 2000; Bhattarai and Baral, 2006). This species is well represented under protected habitats in

the tribal dominated tracts of central India (parts of Bihar, Chhattisgarh and Simlipal region of Orissa) evidently exhibiting trends of semi-domestication/ protection (Duthie, 1960; Wood, 1977; Haines, 1978; Khanna *et al*., 2005). In home gardens in South India (a probable area of domestication) it is commonly cultivated as a perennial but under commercial cultivation mostly as an annual tree. Self sown populations are also seen near areas of cultivation (Haridasan and Rao, 1985; Murthy and Venu, 2005).

The tree is mainly valued for edible pods used as vegetables and pickle. The leaves and flowers are used as vegetables and garnishing food; also sold in the market. Vegetable prepared from leaves is commonly recommended as a special food supplement for rich in iron and calcium (Wealth of India, 1962; Verma *et al*., 1976). Dried leaves are used as condiments. Seeds are consumed after frying like peanuts and edible seed oil used for cooking. The flowers are good source of nectar for honey producing bees. The leaves, roots, flowers and seeds are used in folk remedies for tumours, abdominal tumours, rheumatism and venomous bites (Hartwell, 1967-1971); root as expectorant, mild diuretic, epilepsy, hysteria and stimulant in paralysis (Mughal *et al.*, 1999).

The oil is extracted from seeds (up to 40 per cent) and used for edible purposes, for illumination, cosmetics, soap and lubricant industry (Wealth of India, 1962; Burkill, 1966). The coagulating ability of the seed powder became important for water purification in arid regions (Morton, 1991). Leaves and twigs are used as fodder in many parts of India (Watt, 1889; Parker, 1918). The tree is used as fence and bark is a source of coarse fibre. The seed cake left after extraction of oil is valued as fertilizer.

Domestication trends and changes in useful characters

Response of wild species to domestication process is primarily dependent on the species behaviour to selection process rather than on its acceptability by the natives/local people where it occurs (Diamond, 2002). The plant is considered to have achieved the stage domestication when it reaches at its highest level of genetic modification and human aid is necessary for survival (Harlan, 1975). The process of domestication is likely to be facilitated with high responds to selection and market requirement than its production in natural population (Venturieri, 2001).

Wider adaptability of *M. oleifera* to different agro-climates, cultivation practices and ease to cultivation practices has facilitated its selection for desirable traits during course of selection process. Despite long history of cultivation of *M. oleifera*, the wild types apparently do not much differ in gross morphological characters and propagation aspects except few characters. These facts probably suggested that the crop is still under evolutionary process and thus offers much scope for improvement/ selection for desirable traits.

During the selection process in domestication of cultivated plants distinct changes/modifications occur in a species leading to distinct types from their parental wild ones (progenitors); for example in cereals an unconscious selection of the non-shattering types got selected during preliminary planting by man (Zohary and Hopf, 2000; Venturieri, 2001; Diamond, 2002). The domesticated types grow outside the distributional range of their wild progenitors and have changed morphologically, physiologically and phenologically (Ladizinsky, 1998).

Folk domestication trends evidently exhibit protection mechanism, its gradual effect on enhancing the useful diversity and utilization based socio-economic structure and dependence on local useful genetic resources (Arora 1986; Pandey and Arora, 2004). In areas of natural distribution (foothills of the Himalaya, extending towards Pakistan in the west and central Himalaya and central parts) of *M. oleifera* rich variability in fruit types in wild/ protected and semi-wild populations, with minimal use of species was recorded (Arora and Pandey, 1996; Tiwari *et al*., 2010). In protected/semi-domesticated populations this species was recorded for edible oil by Indian folks (Vishnu Mittre, 1981), for vegetable from pods and leaves by the Gonds and Santhals of Central India, fruit for pickle by tribals of eastern regions and north-eastern India (Jain, 1981; Arora, 1981; Chhetri, 2006) and edible leaves, flowers, fruit in Andaman and Nicobar Islands (Parker, 1918; Bhargava, 1981). However, in the southern states of India, especially in Tamil Nadu and Kerala, *M. oleifera* is frequently cultivated in homesteads as a vegetable crop and for multipurpose uses (Varalakshmi and Devaraju, 2007).

Cultivation of *M. oleifera* in India has been principally for vegetable and not for seed oils (Watt, 1889; Morton, 1991; Joseph, 2007). The wild populations hold more variability in genepool reservoir over the range of distribution of species. The traditional use as a multipurpose species by natives pinpointed accumulation of useful characters/attributes in the protected/semi-domesticated populations. Trend indicating dependence on the species

as locally available genetic resources in the tribal tracts of central and eastern region of India suggested of concentration of diversity, thus the priority areas for genetic resources collection and conservation. The diversity distribution pattern identified the following types of populations:

- Truly localized populations occur as wild trees in the areas of distribution (in western Himalaya and adjoining parts) with minimal plant use.
- Protected populations occur in new dwellings in the forested land, as patchy populations with shorter, hard and bitter fruits reported for multipurpose uses in parts of foot-hill region.
- Selected and semi-domesticated populations occur in community land/forested/ backyards of tribal dwellings in the central and western and eastern plains (Bihar, Upper Gangetic Plains, Orissa) and reported as multipurpose tree with diverse uses.
- Domesticated and improved cultivars grown in farmers field/ land mainly for vegetable purpose (in southern region).

Changes in qualitative and quantitative characters in wild and cultivated types were studied using selected types (41 accessions) (Table 1; Fig. 1 and 2).

Species selected through the process of conscious folk domestication have resulted in developing variation in useful characters as habit, seed yield, shattering of seeds and other economic traits among cultivated types such as *Moghania vestita* (for edible tubers in the Khasi and Jaintia tribal regions), *Digitaria cruciata* var. *esculenta* (minor cereal and as fodder species in the Khasi tribal region); *Coix lacryma-jobi* (for edible soft, thin-shelled, and easy hulling grain types, with bold seeds and high yield) and rice bean/*Vigna umbellata* (for edible grain pulse by tribals of north eastern Himalaya); *Inula racemosa* (for aromatic oil in Western Himalaya in the tribal region of Lahaul) (Singh and Arora, 1972; Arora, 1997; Arora *et al*., 1980a and b).

Trends of domestication are evident through the study of distributional range (of cultivated types growing outside their wild progenitors) and change in morphological, physiological and phenological traits (Ladizinsky, 1998). Under domestication, all the characteristics of plant species for which the selections are made, exhibit distinct changes or modifications. In the present study wild *M. oleifera*, has prominently exhibited fruit characters such as smaller sized, lesser pulpy (poorer food reserves), bitter (defensive mechanism) and fruits borne in clusters with high splitting (adapted for dispersal). In the process of domestication these have shown a change in cultivated types (Table 1).

Table1. Characters in wild and cultivated types in *M. oleifera*

S. No.	Characters*	Wild type	Cultivated type
1	Distribution and habitat	Foot-hills of Himalaya; forested area, near habitation	Mainly in southern region; home gardens, farmers field; sometimes as escape (self sown types)
2	Habit	Perennial; large sized (14 m) trees with broader stem	Perennial and annuals; tree with shorter height (12 m) with narrow stem
3	Mode of reproduction	Through seed	Through seeds and cuttings
4	Leaflets	Smaller (1.1x0.8 cm)	Leaves with pink tinge in petiole, comparatively larger sized leaflets (1.5x1.2 cm)
5	Leaf sheading	Leaf sheading after flowering	Tree bears leaves all throughout the growing period
6	Flowering and fruiting period	One time flowering (February- March); fruiting strictly after the flowering is over (March-May)	Fruiting and flowering simultaneously
7	Flower colour	Generally creamish-white but also pink	Creamish-white with yellow dots
8	Fruit	Fruits smaller (upto 50 cm), 1.0-1.5 cm diameter, cylindrical, tapering, generally borne in clusters of 15-20 fruits, thin walled, less fleshy with bitter	Fruits longer (upto 120 cm), up to 1.8 cm diameter, pale green or red tinged, angular-cylindrical, borne in clusters of 8-10 fruits, thick walled, fleshy with good taste
9	Seed	Smaller (22x11 cm), soft walled, spindle shaped, wings soft membranous, deciduous, seed coat white-ivory, kernel and seed coat normally soft; 15-20 seeds/fruit	Bigger (32x26 cm), three angled, kernel, wings hard smaller, kernel more mealy and seed coat hard, black-brown and persistent; over 25 seeds/ fruit
10	Seed dispersal	Valves split open widely upto the peduncle; seed shattering high	Splitting upto half length, less shattering (fruits still left on tree)
11	Palatability	Less palatable, bitter-semi-bitter	More tasty with mild aroma, improved palatability
12	Oil (%)	18- 24	Upto 20
13	Seedling	Thin with narrow leaflets	Stout with bigger leaflets

* Modified from Arora, 1991

Fig. 1. Tree bearing pods (cultivated type on left and wild type on right side, bearing fruits in clusters) and seedling leaf in cultivated and wild type

Fig. 2. Characters of pod (wild type on left and cultivated on the right side) and seed (on left is wild type with narrow papery wing and white kernel; on right is cultivated type with broader and thicker wing and dark kernel) of *M. oleifera*

However, some traits (like tree bark, branching), seed germination, oil and protein contents in seed kernel, etc.) have shown a marginal distinction in the cultivated types from their wild ones. Further studies are desired to throw more light on changes in characters like thin seed coat and soft fruit wall in wild types to hard seed coat and hard fruit wall in cultivated types. Accumulation of the following useful characteristics/promising attributes were observed in cultivated types:

- Habit: relatively low height (facilitate harvest), flowering and fruiting throughout the year and selection of leafy types (leafy vegetable and fodder yield)
- Economic part: big sized fruits, more pulpy, edible fruits (mesocarp), non-bitter fruits (improved quality); lesser fruit splitting, prolonged fruit availability period (economically viable), much variability in fruit size in cultivated types (selected types)
- Propagation: through seed as well as cuttings
- Protective mechanism: decrease in bitter com-

ponent in protected/ cultivated types (increased palatability)

Recent studies on domestication of indigenous fruit trees in Africa suggested that identification of trees combining a few, rather than many superior traits is preferable to create new cultivars specialised for a particular set of environment and for a set of traits for a single product. In *Choerospondias axillaris* (lapsi–a wild edible fruit), the combination of traits as pulpy fruits recombined with larger sweet types may be desirable to fetch high market of Nepal Himalayas (Paudel *et al*., 2002). In *M. oleifera* also selecting rare genotypes with desirable traits (fruit, oil, ornamental use, etc.) maintaining broader genetic base in all other characteristics, thus, minimising the risk of pest and diseases, would be desirable.

Future Thrust

The wild species of no or minor importance today may assume major significance for tomorrow's generation. Since any kind of breeding work depends on the availability of genetic variability, the first step is collection of germplasm mainly from indigenous sources. In view of the account presented above, it is desirable to undertake detailed surveys, explorations and collection in diversity-rich areas for search of useful types. In view of considerable potential of *M. oleifera* for utilization as an oilseed, fodder and ornamental in the Indian context, this minor cultivated species deserves renewed attention for identification of desirable types. The following thrust areas have been pinpointed:

- Diversity assessment of entire moringa genepool (especially wild/protected and semi-domesticated population) for desirable traits and augmentation of germplasm in gene bank holdings.
- Identification of genotypes with desirable traits (relatively short statured plants with low gestation period, year round fruit bearing, clustered fruits bearing, higher pod yield, fleshy pods and tasty fruits, leafy types, showy flowered types with ornamental value); identification of ecotypes suitable for wide agro-climatic range, for industrial value with higher percentage of oil, etc.
- Validation of centre of origin, diversity, dispersal and domestication through modern tools.

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