Collecting Genetic Resources of Wild *Moringa oleifera* Lam. from Western Himalayas

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The present communication deals with survey, exploration and germplasm collection of wild *Moringa oleifera* Lam. in foothills of western Himalayas. A total of 23 accessions including one cultivated type were collected and conserved at National Bureau of Plant Genetic Resources, New Delhi. Fairly rich variability was observed with respect to several economic traits including cluster bearing, bitter content in fruits, prolific yield, etc. in wild/semi-wild moringa germplasm. Decline in population of young plants and seedlings in their native range was observed. Brief observations on botany of wild types collected, ethnobotany and conservation are also highlighted.

Key Words: Collection, *Moringa oleifera***, Vegetable, Western Himalayas, Wild**

Introduction

The genus *Moringa* Adans. (family Moringaceae) has 13 species (Olson, 2003), with centre of diversity in the Horn of Africa (National Research Council, 2006). Two species *viz*. *M. oleifera* Lam. (syn. *M. pterygosperma* Gaertn.) and its closest relative *M. concanensis* Nimmo occur in India. *M. oleifera* (the drumstick tree, horse radish tree, West Indian Ben, *murungai*, *sainjna*) is a medium sized fast-growing and extremely adaptable tree, native to India and Pakistan and occurs wild in the foothills of western Himalayas from North West Frontier Province (now Khyber Pakhtunkhwa), Pakistan in the west (Anwar and Rashid, 2007) to Uttarakhand up to 700 m above mean sea level (msl), and also northern parts of Uttar Pradesh (Kanjilal, 1933). It is widely cultivated as multipurpose tree species and naturalized in the tropical and sub-tropical regions of the world. Plants are principally utilized in India for fruit and leaves as vegetable especially in peninsular region, to some extent for edible flowers at local level and seed oil having industrial value and also as medicinal plant. Since ages in south India, perennial types had been cultivated as single tree in homesteads, cattle sheds, field boundaries, fences and as groups of trees on village waste lands, and rarely as intercrop/alley crop. In the last two decades improved annual cultivars (seed-propagated ones) have replaced around 60% of perennial moringa (stem-propagated) cultivating areas in south India (Rajangam *et al*., 2001).

Despite the rich nutritional content in fruit, leaf and its potential in industry, moringa has been denied attention for improvement and commercial utilization particularly in northern India. Because of high heterozygosity, genotypes existing in varied geographical areas provide scope for crop improvement programmes (Sundarajan *et al*., 1970) through broadening the genetic base. It is probable that moringa germplasm collected from centre of origin can show greater genetic diversity and also superior in having high functional property (Asian Vegetable Research and Development Centre, 2002; Bosch, 2004). Moreover germplasm with specific traits such as cluster-bearing habit, low tree canopy, tolerance to biotic and abiotic stress (Rajangam *et al*., 2001) and high seed oil are the desirable traits in moringa improvement programmes. The national and regional collections mainly represent variability in cultivated gene pool. Hence an exploration was undertaken to survey and collect the wild *M. oleifera* germplasm in parts of Punjab, Himachal Pradesh and Haryana states of India.

Materials and Methods

An exploration was undertaken in the foothills of western Himalayas (30° 75’ to 32° 26’ N latitude; 75° 40’ to 76° 90’ E longitude; altitude ranging from 230 to 700 m above msl) covering the eleven districts *viz*. Ludhiana, Hoshiarpur, Pathankot, Gurdaspur, Ropar (Punjab), Kangra, Una, Bilaspur, Hamirpur, Solan (Himachal Pradesh) and Panchkula (Haryana) of India during May 2010 (Fig. 1). General observation on occurrence under

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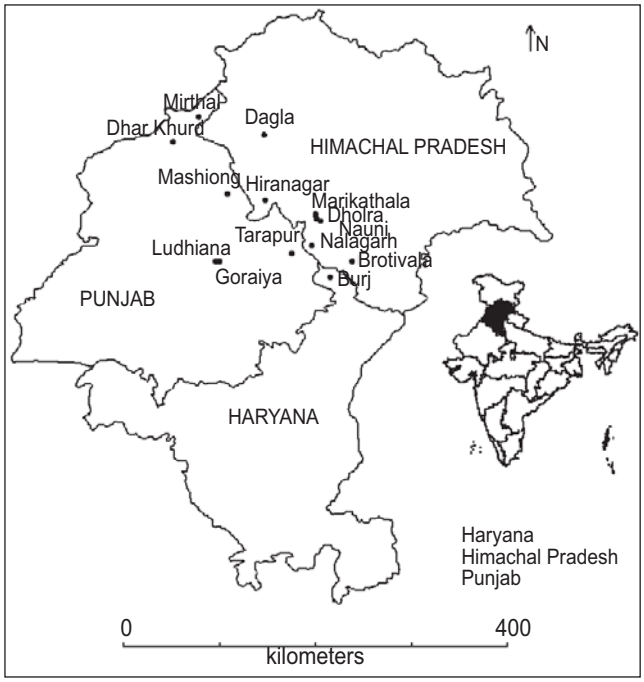

Fig. 1. Sites of *Moringa oleifera* germplasm collected in western Himalayas

natural conditions, indigenous knowledge was validated through local people. Vouchers of herbarium specimens and seed samples (HS20281, HS20282, HS20285; SS2893-2902) were deposited in National Herbarium of Cultivated Plants, NBPGR, New Delhi.

Sampling and Data Recording

Collections were made following random sampling from a population of 10 to 20 plants except for selected traits in which biased sampling on individual trees was made (trees were also marked for future bud-wood collection). Passport data on place of collection, latitude, longitude, altitude, vernacular name, frequency of occurrence, sample type, sampling method, biological status (*i.e.* wild, semi-wild, cultivated), associated vegetation and habitat/ecology were recorded at each site along with distinct traits like bitterness in fruit (as per respondents), fruit-bearing nature, productivity status, etc. Each collection was assigned with a unique collector number. Tree-dried (matured) fruits were harvested and ten representative fruits were selected for recording the data on fruit length, girth and colour and seeds per fruit. Seed samples were randomly taken for recording 100-seed weight while 20 representative seeds were selected for studying seed colour, prominence of wings and ease of seed coat detachability (recorded using arbitrary means), kernel per cent, size and shape.

Seedling Establishment Studies

A total of 50 seeds of each accession were put in for germination tests using paper towel method. The germinated seeds were shifted at two-leaf stage (15 days after planting) in pots containing sand, soil and farmyard manure in equal proportion. Seedling growth was recorded (10 seedlings/accession) after 15, 30 and 45 days. Notes on seedling establishment, variation in seedling morphology, etc. were also recorded. One set of germplasm of collected material was conserved in genebank at NBPGR, New Delhi.

Results and Discussion

General and Habitat Particulars

Moringa oleifera is known by different names in areas explored *viz*. *Sunna* in Una district, *Rasunna* in Bilaspur district, *Sunana* in Kangra district and *Swejna*/*Saijhna* in other areas. In most cases, trees were of 35-100 year old, juvenile plants were seen only sparingly in wild and semi-wild localities. Most of the populations were seen near human habitations and field boundaries (hereafter called as semi-wild), in such localities, all the respondents (approx.100) informed that all trees were self-sown. Good population stand was noticed in places namely Dhar Khurd (20 plants) in Gurdaspur district, Dagla (50) and Pind Padhya (20) in Kangra district, Gandawal (100) in Una district, Bilaspur (100), Nauni (50) and Kandrour-Bilaspur (100) in Bilaspur district, Chandimandir-Burj (300) in Panchkula district, Anandpur Sahib-Kiratpur Sahib (50) in Ropar district and Mirthal-Pathankot (100) in Pathankot district.

In few areas, plants were seen truly wild, occurring in stands as a component of the mixed broad-leaved/conifer forest or *khair* [*Acacia catechu* (L.f.) Willd.] forest with associated species like *Cassia fistula* L., *Syzygium cumini* (L.) Skeels, *Bombax ceiba* L., *Holoptelea integrifolia* (Roxb.) Planch., *Dendrocalamus strictus* (Roxb.) Nees, etc. The soils were well drained with often low organic matter. The wild trees were not distinguishable from the semi-wild ones on any consistent character. Places where truly wild population noticed were Batauli in Bilaspur district (31° 34’ N; 76° 80’ E; 547 m; 20 plants), Bhojpur-Jakhbar in Kangra district (32° 14’ N; 75° 71’ E; 347 m; 30), Rohin in Bilaspur district (31° 34’ N; 76° 75’ E; 600 m; 20) and Baduhi in Una district (31° 57’ N; 76° 19’ E; 350 m; 20) while single trees of landraces/cultivars introduced from peninsular India were observed under cultivation in kitchen garden for fruit purpose in few places.

Morphological Observations

Pollarded trees with young flush were noticed commonly in Himachal Pradesh and Panchkula district of Haryana but sparingly in Punjab. In non-pollarded trees, fruits at dehiscing stage were seen without any leaves or with new leaves. Gregarious bearing and fruit bearing in huge bunches were occasionally noticed in Punjab. In many places, the plants were noticed with slender as well as normal-sized fruits in adjacent branches, indicating the limitation of source preventing sink to develop to normal size. It signifies that better agronomic practices may boost the productivity. In general, irrespective of altitude, wild (hereafter used in the context for both wild and semi-wild populations) plants were abundant fruit-producers comparing to the cultivated types. Sometimes dehiscing fruits were noticed with reddish tinge. Although a cross-pollinated species, self pollination might be operating in wild plants in significant manner since a single plant sets fruits abundantly without having nearby plants for at least one kilometre, supporting the earlier statements on moringa pollination system by Jyothi *et al*. (1990) and Muluvi *et al*. (2004). Botanical studies of cultivated and wild types revealed some distinction (Table 1) which is hardly ever mentioned in botanical description of this species, since the latter is mainly based on the cultivated type.

Extent of Variability and Potential Value

The knowledge on the extent of variability in the morphological characters serves as a base for germplasm utilization. Out of 23 accessions collected from diverse habitats, 22 were taken for present analysis; one being collected in the form of vegetative material. Fruits in the wild types were bitter/semi-bitter and even free from bitterness as informed by local people. Three wild plants of 50-100 year old (including KP/PKS/RC/10-15) yielding bitter-free fruits were found in Batauli and Palthi (in Bilaspur district) and were occasionally used in culinary purpose like in South India. Variation was also noticed in leaflet size, dry pod colour (reddish brown/light brown/dark brown), bearing nature, prominence of seed wings, strength of seed coat, kernel shape (round/ovate/spindle) and seed colour (Table 2, Fig. 2). KP/PKS/RC/10-3, 4, 8 and 15 bore fruits in huge clusters. The seed of all the wild accessions possessed white seed coat colour except one (KP/PKS/RC/10-4) having ivory-white colour. Anwar and Rashid (2007) also reported pale-yellow to whitish seed coat colour in wild *M. oleifera* collected from Pakistan. Ovate kernel shape was exhibited by 80 % of the accessions. All the accessions had prominent wings (measuring 0.5-0.9 cm) except KP/PKS/RC/10-5, which had rudimentary or less developed wings. In line with the latter sample, a cultivated sample with wingless seeds was reported in China (Lianli and Olson, 2001). Unlike the thick and hard seed coat in cultivated sample (KP/PKS/RC/10-23), wild materials had relatively fragile and papery seed coat which could be broken with thumb pressure.

In addition to varying levels of fruit yield in individual plants sampled, good range of variation was noticed in quantitative characters studied such as fruit length (22.67-60.44 cm), fruit girth (2.20-3.44 cm), 100-seed weight (6.40-14.70 g), percentage of kernel to seed (67.80-82.21), kernel length (6.27-10.95 mm) and kernel diameter (3.36-8.52 mm) except one *i.e.* seeds/fruit which exhibited a narrow range of 12.10 to 18.70. High amount of variability (as expressed by CV) was exhibited in the traits like fruit length, 100-seed weight and kernel diameter. Raja and Bagle (2008) reported that fruit length and girth have positive direct effect on yield per plant in annual moringa. In this regard, KP/PKS/RC/10-20 was noteworthy to mention in having appreciable fruit length (60.44 cm) and girth (3.13 cm).

Table 1. Morphological comparison of wild and cultivated types of *Moringa oleifera*

Particulars	Wild†	Cultivated*
Leaf	Petiole strictly pale green in colour	Petiole also violet-purple
Flower	White or pink in colour	White or yellowish white, rarely pink
Fruit	Size 15-50(-60) x 1.0-1.5 cm, thin, slender, less fleshy, bitter; 15-20 seeds/fruit	(15-)20-120(-150) x 1.3-2.5(-3.3) cm, thick walled, fleshy, bitter-free; up to 26 seeds/fruit
Seed	Size (with wings) 15-30(-32) x (6-)8-12 mm, seed coat white, mealy, fragile; wings soft, membranous, caducous	25-32(-40) x 10-26(-30) mm; seed coat black to brown at least in the ¾ area from centre, hard; wings smaller, persistent
Phenology	Deciduous (during winter); one time flowering (February-March) followed by fruiting (March-May); leaf emergence (February-May)	Evergreen (occasionally semi-deciduous during winter in north India); flowering almost throughout the year with less pace in winter

*References: Resmi *et al*. (2005); Parrotta (2009) and Radovich (2009)
†Based on observations recorded on approx. 220 trees in area of exploration

Table 2. Fruit and seed characters of *Moringa oleifera* germplasm collected during exploration

S.N.*	Fruit length (cm)	Fruit girth (cm)	Seeds per fruit	100-seed weight (g)	Per cent kernel	Kernel length (mm)	Kernel diameter (mm)	Fruit color (dry)	Kernel shape	Wing prominence	Seed-coat detachability	Remarks
1	33.34	3.44	15.40	14.70	69.68	10.32	6.41	LB	Ovate	++	†	–
2	40.27	2.85	18.70	12.08	76.45	10.19	7.26	RB	Ovate	++	†	Gregarious bearing
3	44.38	3.06	15.30	11.24	72.95	9.18	6.11	DB	Ovate	++	†	Gregarious bearing
4	28.31	2.53	16.60	10.22	79.35	8.91	5.88	LB	Ovate	+++	†	Gregarious bearing
5	35.48	2.92	14.10	8.64	67.81	7.41	3.36	RB	Ovate	+	††	Big-sized leaflet
6	22.67	2.34	13.50	10.32	82.21	6.76	5.05	RB	Ovate to round	++	†	Big-sized leaflet
7	37.40	2.83	14.20	9.38	76.57	8.47	5.07	LB	Ovate	++	††	–
8	44.55	2.79	14.30	9.04	76.96	9.23	6.72	RB	Ovate	+++	†	Gregarious bearing
9	45.19	2.97	16.10	10.04	73.71	8.04	4.18	RB	Ovate	+++	†	Gregarious bearing
10	35.34	2.47	15.30	9.98	81.17	10.28	6.85	LB	Ovate	+++	†	Less-bitter fruits; big-sized leaflet
11	47.18	2.96	14.20	13.78	76.92	10.39	8.52	LB	Ovate	++	††	–
12	25.34	2.20	13.20	12.29	68.93	10.95	5.88	LB	Ovate		††	–
13	50.64	2.66	13.60	7.42	72.78	6.33	4.65	LB	Ovate	++	†	–
14	40.32	2.46	13.70	11.68	80.90	10.12	6.52	LB	Ovate	++	†	–
15	45.21	2.75	14.90	12.22	77.33	9.55	6.84	DB	Ovate	+++	†	Fruits bitter-free
16	47.89	2.57	13.90	7.89	79.05	8.78	5.54	LB	Ovate		††	–
17	30.77	2.75	12.30	6.40	72.88	6.27	4.02	LB	Ovate to round	+++	†	–
18	37.38	2.81	12.10	10.24	70.31	8.86	5.13	LB	Ovate	+++	†	Big-sized leaflet
19	57.34	2.86	17.80	8.37	71.88	9.31	5.76	RB	Ovate	+++	††	–
20	60.44	3.13	16.40	8.44	72.04	10.11	6.07	LB	Spindle	++	†	–
21	42.53	2.68	13.50	11.34	67.80	9.50	5.33	LB	Spindle	++	†	–
22	30.56	5.62	15.30	16.78	76.98	10.27	16.46	DB	Round	+++	†††	Fruits fleshy
Mean ± S.E	**40.57±2.11**	**2.76±0.06**	**14.72±0.37**	**10.27±0.46**	**74.65±0.98**	**8.97±0.30**	**5.79±0.26**					
Range	**22.67-60.44**	**2.20-3.44**	**12.10-18.70**	**6.40-14.70**	**67.80-82.21**	**6.27-10.95**	**3.36-8.52**					
CV (%)	**23.88**	**10.23**	**11.45**	**20.43**	**5.99**	**15.20**	**20.62**					

*Serial nos. 1-22 indicates collector nos. KP/PKS/RC-10-1 to KP/RKS/RC-10-22 respectively, last one is the cultivated type which is not considered for mean, range and CV; LB - Light brown, RB - Reddish brown, DB - Dark brown; † - Easy, †† - Slightly difficult, ††† - Difficult

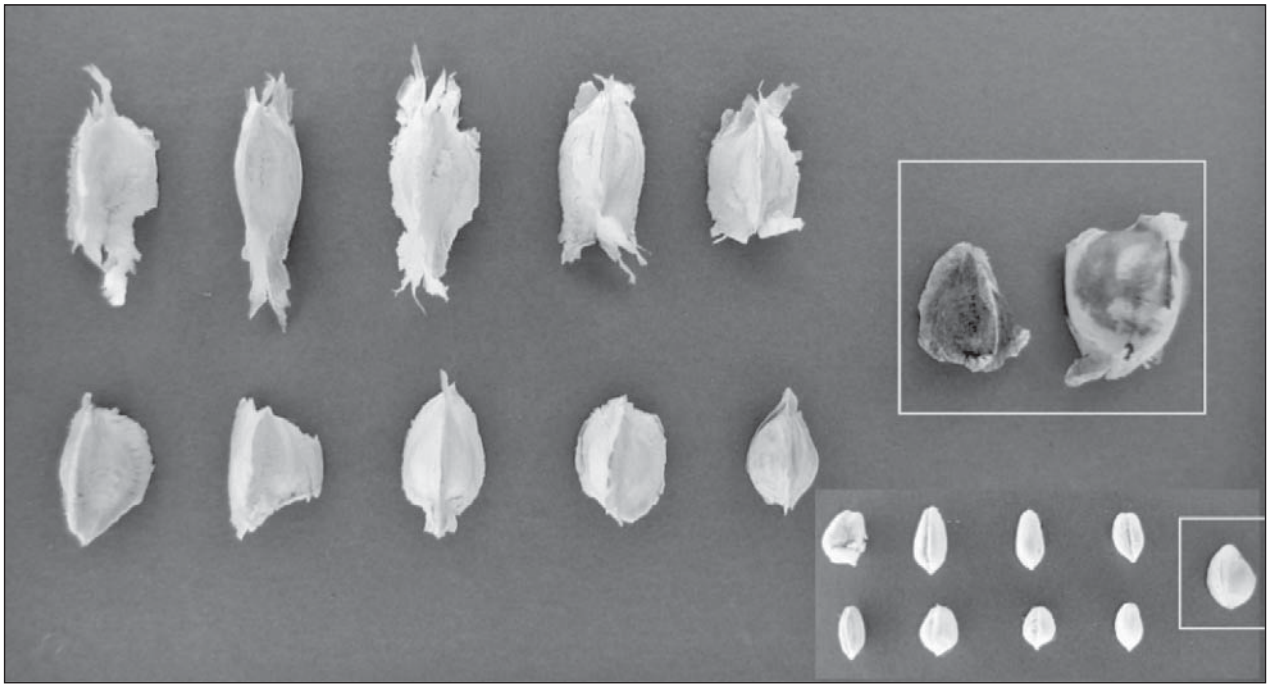

Fig. 2. Variability in seed and kernel (inset) characters of *Moringa oleifera* germplasm collected (cultivated sample in box)

The traits namely number of seeds/plant, 100-seed weight, kernel weight and size will have significance in identification of the oil-yielding types. The oil analysis of seeds of wild germplasm ranged from 20.90 to 36.80% while the cultivated sample yielded 39.20% (Dr. J Radhamani, NBPGR, pers. comm.). The present study confirms the findings of earlier reports such as Anwar and Rashid (2007) and Parrotta (2009) with respect to lower values of oil% (data not presented), fruit length, number of seeds/fruit, 100-seed weight and kernel size in wild germplasm in comparison with cultivated ones. Seed oil of wild *M. oleifera* from native range in Pakistan was found to have quality attributes identical with the cultivated moringa oils reported in literatures, hence, could be employed for edible and commercial applications (Anwar and Rashid, 2007).

Ethnobotany

Immature fruits of wild types were generally bitter, hence not generally used for vegetable purpose. In most areas surveyed, young fruits (10 day after anthesis; 10-15 cm long) were occasionally employed for making pickle. Flowers were less commonly used in *raita* (a dish prepared from boiled flowers and curd) preparation in Gandawal in Una district. At Burj village (Panchkula district), contractors were routinely collecting the flowers from wild trees (by destructive harvesting) in jute bag (moist) for sale in big markets (₹ 50/kg). Arora and Pandey (1996) also reported that young flowers (both pink and white forms) in packets are commonly sold during February-March in city markets of northern India. Also people seldom cooked flowers as informed in Auhar and Dagli villages in Bilaspur district. Roots of three months old seedlings (45-60 cm long) were said to be used for pickle making and sparingly sold in market of Punjab and parts of Kangra district of Himachal Pradesh. For this, after one and a half month in nursery, seedlings were headed back to 30 cm high so as to enable root growth for another one and a half month.

Study on seedling establishment and some considerations on conservation

Though seeds are produced in large quantity, natural regeneration of moringa seems to be poor on natural habitats *i.e.* a very few young plants were located in those areas. Bosch (2004) stated that *M. oleifera* is probably extinct in its natural state, although which is not evident in the present exploration-based study. In the present experiment, the collected germplasm showed about 60-90% germination (data not presented) which is in line with that of cultivated material (Parrotta, 2009). Seedling establishment in pots was about 80-90%, which is quite satisfactory except in KP/PKS/RC/10-13 and 14. These two accessions failed to establish in pots owing to fungal damage in seed coat immediately after germination (radicle emergence) The survived seedlings revealed variable growth rates and some

variation with respect to leaflet size and shape among the accessions studied. It was apparent from the present study that seedlings suffer less mortality under care. Nduwayezu *et al*. (2007) reported that provenances having seeds with big-sized kernel yielded high plant survival and growth rates in *M. oleifera* under Botswana conditions. This statement is corroborated to some extent in this work too but needs more fine-tuning of experimental conditions to have a meaningful conclusion.

Throughout the areas explored, though wild *Moringa* plants were not felt as so important (probably due to the availability of alternatives), villagers never cut the trees. Thus, the probable reasons for poor natural regeneration might be rapid decline in seed viability, poor competition by seedlings for light and soil moisture with associated vegetation particularly grasses, pressure from browsing animals and urbanization. Seeds have no dormancy period and lose viability within three months (Sharma and Raina, 1982; Morton, 1991). In natural conditions, seeds are shed during April-May and monsoon begins during July, i.e. at least after 60 days only conducive situation might occur, by the time, majority of the seeds might lose their viability. Authors also observed that fallen fruits are highly prone to attack by termites.

Conclusion

In view of increasing importance of *M. oleifera* in terms of vegetable and industrial value in Indian and world markets, respectively, this under-utilized species deserves renewed attention for identification of the desirable traits, for which collection of germplasm from its native areas is of utmost importance. This species responds well to vegetative propagation, hence, providing an opportunity for the breeders/germplasm curators to secure the genetic variation created/collected. Studies on factors affecting natural regeneration of this species and seed conservation are required to be investigated.

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