Indian J. Plant Genet. Resour. 28(1): 117-122 (2015)
DOI 10.5958/0976-1926.2015.00015.7

Morphological Characterization of a Few Farmers'-Identified Unique Aromatic Pickle Mango (*Appemidi*) Varieties of the Central Western Ghats

Manohar Sunagar[1], R Vasudeva[1*], Bhuwon R Sthapit[2], VA Parthasarathy[3] BMC Reddy[3] and V Ramanatha Rao[4]

[1]*Department of Forest Biology and Tree Improvement, College of Forestry Sirsi-581401, University of Agricultural Sciences, Dharwad-580001, Karnataka, India*
[2]*Bioversity International-Nepal Office, Dharahara, Pokhara-11, Nepal*
[3]*ICAR-Indian Institute of Horticultural Research, Bengaluru-560089, Karnataka, India*
[4]*Bioversity International, Rome, Italy*

(Received: 14 January 2015; Revised: 8 February 2015; Accepted: 16 February 2015)

Aromatic pickle mango (locally called *'Appemidi'*) is a special type of mango (*Mangifera indica* L.) harvested and semi-domesticated from riverine habitats of the central Western Ghats, India. Recently, it has been provided with the geographical indication (GI) tag. These types are recognized by the local people based on their aroma and taste apart from fruit shape and size. In spite of its commercial importance, there are very few attempts to formally characterize these types for further use. Twelve farmers' identified varieties collected from a fifteen-year-old mango orchard were characterized adopting standard mango descriptors developed by the IPGRI. In the present study 12 varieties of aromatic pickle mango were characterized through a set of distinguishing traits and delineated adopting simple forking method to individual varieties unambiguously.

Key Words: *Appemidi,* Aromatic pickle mango, Descriptors, Farmers' varieties, Morphological traits

Introduction

India is the regarded as the centre of origin and the primary centre of diversity of mango harboring perhaps the largest gene pool with over 1500 mango cultivars (Mukherjee, 1985). Apart from eating fresh fruits, a wide array of products ranging from jam, jelly, leather, squash, wine, *etc.* are prepared using this fruit. Different stages of fruit development are used to prepare these products. One such unique preparation is pickles of highly aromatic mango types in their tender, un-ripen stage. In the central Western Ghats of Karnataka state, India, these effervescent fruit types are locally termed as "*appemidi*" and extensively collected from the wild habitats up to today (Vasugi *et al*., 2012; Bhat *et al*., 2013; Vasudeva *et al*., 2011). Unlike commercial mango, "*appemidi*" fruits are extremely sour and far from sweet taste and hence are not used as edible fresh fruits, but are valued for its aroma. *Appemidi* fruits are processed into pickle which is a widely used and appreciated side dish of almost every single meal in the Central Western Ghats. For a common man of this region, no meal is complete without the extraordinary effervescent taste of these *'appemidi'* pickles (Vasudeva and Rajeshwari, 2014). Because of this deep cultural attachment, people have recognized several hundred pickle-mango types from the wild habitats. These types are recognized by the local people based on their aroma and taste apart from fruit shape, size. Unique types of *'appemidi'* have been identified and domesticated/introduced in home gardens by many households and were extensively collected by farmers. It is distinct from other cultivated fruit varieties with respect to morphological characters such as fruit size, shape, taste, aroma, crown shape, height, and resistance to pest and diseases. The immature fruits are especially suitable for pickling and are in more demand in the market. Very recently, Government of India has also accorded a "geographical indication (GI)" tag to *'appemidi'* types (Source: http://ipindia.nic.in/girindia/images/RegGis.gif; Gautam *et al*., 2012). Despite being a valued local commodity and commonly used side dish, with multiple distinctive types and varieties locally recognized, as well as high importance in rural people's livelihoods little research has been done to systematically characterize the range of available types (Vasugi *et al*., 2012).

Characterization of wild types and semi-domesticated

**Author for Correspondence: E-mail: vasudevar@uasd.in*

types is necessary as it forms the basis for discerning farmers' varieties, subsequent registration of the same and further genetic improvement. Community management and domestication of *'Appemidi'* resources are being addressed under the GEF-UNEP project titled "Conservation and sustainable use of cultivated and wild tropical fruit diversity: promoting sustainable livelihood, food security and ecosystem services". Being implemented in 18 communities of India along with six communities each in Indonesia, Malaysia and Thailand, the immediate objective of the project is to conserve tropical fruit tree genetic resources *in situ* and on-farm through strengthening capacity of farmers, user groups, local communities and institutions to sustainably apply good practices and to secure benefits (Sthapit *et al.*, 2013).

Materials and Methods

The study material was collected from a fifteen-year-old mango orchard of a custodian farmer (Sthapit *et al.*, 2013) located at *Salkani* village, situated at about 17 km away from the College of Forestry, Sirsi (14^0 37' N latitude and 74^0 51'E longitude; 650 msl), India. The area falls in the central Western Ghats eco-region, which is one of the hotspots of biological diversity of the world. This farmer has scrupulously maintained dozens of aromatic pickle mango types in his 7 acre orchard obtained through grafting of the original mother trees from natural habitats. The orchard has been raised on a fairly plain land with a uniform spacing of 5m between rows and between trees. He has been recognized as a custodian farmer of *'appemidi'* recently by the Bioversity International (Sthapit *et al*., 2013). Twelve farmers' identified varieties considered in the study and their special uses are shown in the Table 1. These varieties have been selected from the natural populations of *'appemidi'* by the custodian farmer for multiple uses as whole fruit pickle, cut pickle, propagated through vegetative grafting and today well accepted by the farming communities for their good qualities (Vasudeva and Rajeshwari, 2014).

The morphological characterization was done adopting standard mango descriptors developed by the IPGRI (IPGRI, 2006). Three ramets (*i.e*. vegetatively propagated saplings of the mother tree) per variety were considered for the observations. Only when traits were consistently expressed by all the three ramets, the variety was selected for evaluation. The morphological characterization is carried under four broad category such as i) Tree descriptors, ii) Leaf descriptors, iii) Flower descriptors, and iv) Fruit descriptors as prescribed by the IPGRI (IPGRI, 2006). All the varieties focused in the study are 'grafted' types, had similar trunk circumference and crown diameter facilitating the comparison for other characteristics. From every tree, a minimum of 10 leaves, five inflorescences, and 20 fruits were considered to take the observations on quantitative traits. The data on qualitative traits were observed for two seasons.

Results and Discussion

Tree Descriptors

Tree growth habit, foliage density and crown shape were considered under the tree morphological descriptors (Table 1). With respect to tree growth habit, except

Table 1. Characterization of selected farmers' varieties of aromatic pickle mango using tree morphological descriptors

S. No.	Name of the Farmers' varieties	Specific use	Tree type	Tree growth habit	Foliage density	Crown shape
1	*Malangi*	Whole tender mango pickling	Grafted	Spreading	Intermediate	Broadly pyramidal
2	*Mavinakatta*	Whole tender mango pickling	Grafted	Spreading	Dense	Oblong
3	*Dannalli*	Whole tender mango pickling	Grafted	Spreading	Intermediate	Oblong
4	*Kalkai*	Whole tender mango pickling	Grafted	Spreading	Dense	Semi circular
5	*Haldota*	Whole tender mango pickling	Grafted	Erect	Dense	Oblong
6	*Nandgar*	Whole tender mango pickling	Grafted	Spreading	Dense	Oblong
7	*Ananth bhatta*	Whole tender mango pickling	Grafted	Spreading	Sparse	Oblong
8	*Purappe mane*	Whole tender mango pickling	Grafted	Spreading	Intermediate	Semi circular
9	*Kadigai*	Sliced mango pickling	Grafted	Spreading	Intermediate	Semi circular
10	*Karolla*	Sliced mango pickling	Grafted	Spreading	Sparse	Semi circular
11	*Mudgar kosgai*	Sliced mango pickling	Grafted	Spreading	Dense	Semi circular
12	*Gadehalli kuchagai*	Sliced mango pickling	Grafted	Spreading	Dense	Oblong

'*Haldota*' variety, which showed an 'erect' type, all other varieties were categorized as 'spreading' type. Except '*Ananthabhatta*' and '*Karola*' varieties, all others showed 'intermediate' to 'dense' foliage. '*Malanji*' variety recorded 'pyramidal crown' while others were either 'oblong' or 'semi-circular'. However it is likely that the crown shape might have been slightly altered through the management.

Leaf Descriptors

The aromatic pickle mango varieties considered in the study did not differ with respect to leaf lamina shape and showed 'oblong' leaf shape (Table 2). Leaf apex shape was generally 'acute' except in '*Kalkai*', '*Kadigai*' and '*Gadihalli Kuchagai*' varieties. The leaf base shape showed only two variants *viz*. 'acute' and 'obtuse'. Similarly leaf margin was either 'wavy' type or 'entire' type. The colour of the matured leaves ranged from 'pale green' to 'dark green' colour. The most distinctive trait used by the farmers to identify '*Nandagar*' variety was the slight reddish tinge on the leaf petiole.

The range of leaf blade length varied from 16.98 to 25.03 cm (Table 2). This is perhaps much smaller than the fruit varieties. '*Kadigai*' variety showed the largest leaf blade length (25.03 cm), while a minimum was observed in '*Malangi*' (16.98 cm). Characteristically '*Dannalli*' and '*Kadigai*' varieties had a very good shininess of leaves; while strong leaf fragrance was observed in '*Anantabhatta*' and '*Mudgar kosagai*' varieties. With respect to fragrance, '*Ananthabhata*' variety showed the strongest aroma in the leaf.

Flower Descriptors

Among the floral traits, variety '*Purappe mane*' recorded a slight 'pinkish' shade which was distinctive from all other varieties evaluated.

Fruit Descriptors

For the purpose of pickling, farmers harvest aromatic fruit types of different varieties at different stages. 'Whole fruit pickle varieties' are harvested at very immature stage while the 'sliced pickle' varieties are harvested at mature but unripe stage (Table 1). It is at these stages distinctive traits are observed by the farmers to recognize the varieties. Hence it is important to evaluate them at appropriate stages to determine the best characters for pickling. For this reason, morphological characterization of the aromatic pickle mango varieties has been done at two different stages of fruit development. For all the whole pickle mango varieties (S.No. 1-8; Table 3), tender stage was considered while for the ''sliced pickle mango' types (S.No. 9-12; Table 3) fully developed but immature stage was considered. All 'sliced pickle mango' types were 'roundish' with 'round' fruit apex and 'smooth surface texture'. Variety '*Haldota*' showed 'Serpentoid' fruit shape which is one of most preferred varieties by farmers. With respect to fruit beak type 'pointed' and 'perceptible' types were predominant, and 'prominent type' of fruit beak was observed in only two varieties '*Haldota*' and '*Anantabhatta*'. Among all the varieties it was observed that there were an equal proportion of 'waxy' and 'non-waxy' fruits. There were no specific

Table 2. Characterization of selected farmers' varieties of aromatic pickle mango using leaf morphological descriptors

S. No.	Name of the Farmers' varieties	Leaf blade shape	Leaf apex shape	Leaf base shape	Leaf margin	Colour of fully developed leaf	Leaf blade length (cm)	Leaf blade width (cm)	Petiole length (mm)	Shininess*	Leaf fragrance**
1	*Malangi*	Oblong	Acute	Acute	Wavy	Green	16.98	4.45	3.31	0	1
2	*Mavinakatta*	Oblong	Acute	Acute	Wavy	Dark green	20.48	4.69	3.74	1	1
3	*Dannalli*	Oblong	Acute	Acute	Wavy	Dark green	18.49	4.34	3.32	2	1
4	*Kalkai*	Oblong	Obtuse	Obtuse	Entire	Pale green	18.24	5.66	2.83	1	1
5	*Haldota*	Oblong	Acute	Obtuse	Entire	Green	19.37	6.81	3.55	1	1
6	*Nandgar*	Oblong	Acute	Acute	Entire	Pale green	20.19	4.81	3.67	1	1
7	*Ananth bhatta*	Oblong	Acute	Acute	Entire	Pale green	19.08	4.39	2.83	1	2
8	*Purappe mane*	Oblong	Acute	Acute	Wavy	Dark green	17.51	5.09	2.46	1	1
9	*Kadigai*	Oblong	Acuminate	Acute	Wavy	Dark green	25.03	6.37	3.62	2	1
10	*Karolla*	Oblong	Acute	Obtuse	Wavy	Green	21.63	6.39	2.99	1	0
11	*Mudgar kosgai*	Oblong	Acute	Obtuse	Entire	Green	18.5	4.26	2.96	0	1
12	*Gadehalli kuchagai*	Oblong	Acuminate	Acute	Wavy	Green	20.25	4.86	4.64	0	0

* 0= no shine; 1 = moderate shine 2 = good shine

** 0 = Not fragrant; 1 = moderately fragrant; 2 = strongly fragrant

Table 3. Characterization of selected farmers' varieties of aromatic pickle mango using qualitative fruit morphological descriptors

S. No.	Varieties	Fruit shape	Shape of fruit apex	Skin colour of the fruit	Fruit-beak type	Skin waxiness	Depth of fruit-stalk cavity	Fruit-neck prominence	Pulp aroma	Mature fruit colour
1	*Malangi*	Oblong	Obtuse	Green	Perceptible	Non-waxy	Absent	Slightly prominent	Strong	Greenish yellow
2	*Mavinakatta*	Oblong	Obtuse	Dark green	Pointed	Non-waxy	Absent	Absent	Strong	Greenish yellow
3	*Dannalli*	Oblong	Obtuse	Green	Pointed	Non-waxy	Absent	Absent	Intermediate	Yellow
4	*Kalkai*	Roundish	Round	Dark green	Perceptible	Waxy	Absent	Very prominent	Intermediate	Greenish yellow
5	*Haldota*	Serpentoid	Acute	Green	Prominent	Waxy	Absent	Slightly prominent	Intermediate	Yellow
6	*Nandgar*	Oblong	Obtuse	Greenish yellow	Pointed	Waxy	Absent	Slightly prominent	Intermediate	Greenish yellow
7	*Ananth bhatta*	Extra oblong	Acute	Green	Prominent	Non-waxy	Absent	Absent	Strong	Yellow
8	*Purappe mane*	Oblong	Round	Dark green	Perceptible	Waxy	Absent	Slightly prominent	Intermediate	Greenish Yellow
9	*Kadigai*	Roundish	Round	Dark green	Perceptible	Waxy	Shallow	Absent	Mild	Reddish Yellow
10	*Karolla*	Roundish	Round	Greenish yellow	Perceptible	Waxy	Medium	Prominent	Mild	Yellow
11	*Mudgar kosgai*	Roundish	Round	Green	Pointed	Non-waxy	Shallow	Absent	Mild	Yellow
12	*Gadehalli kuchagai*	Roundish	Round	Greenish yellow	Pointed	Non-waxy	Shallow	Absent	Mild	Yellow

associations among the six evaluated fruit characteristics as presented in Table 4.

As shown in the Table 4, all 'whole-fruit pickle' varieties (S.No. 1-8) showed smaller diameter (ranging from 2.87 to 4.29 cm) and fruit length (ranging from 4.84 to 7.62 cm); while the 'sliced-pickle' varieties (S.No. 9-12) recorded larger diameter (ranging from 5.07 to 8.22 cm) and larger length (ranging from 6.30 to 10.4 cm). All 'whole-fruit pickle varieties' did not show any stalk cavity.

For the general characterization of the aromatic pickle mango varieties, the observations are also recorded after fully ripening of fruits of all the varieties (Table 4). Varieties used for 'sliced pickles' generally possessed larger mass and mild aroma than those used as 'whole-fruit pickle'. Matured fruit colour of all the 'sliced pickles' varieties was 'yellow'. In general the 'whole fruit pickle' varieties showed greenish yellow colour.

In the era of IPR issues, characterization of varieties assumes greater importance. The application of morphological markers is the simplest of the methods of characterization that could be repeatedly done and effective used for IPR issues (Lyngdoh *et al*., 2007). Since the published descriptor lists are readily available for the morphological markers, it can be carried out *in situ*, is relatively low-cost and easy to perform.

Table 4. Characterization of selected farmers' varieties of aromatic pickle mango using quantitative unripe and mature fruit morphological descriptors

S. No.	Varieties	Fruit diameter (cm)	Fruit length (cm)	Fresh fruit weight (g)	Mature fruit diameter (cm)	Mature fruit length (cm)	Mature fresh fruit weight (g)
1	*Malangi*	3.68	4.76	25.73	4.82	6.49	70.20
2	*Mavinakatta*	3.63	6.00	26.11	5.49	8.06	110.13
3	*Dannalli*	4.29	6.78	42.97	5.48	8.81	122.12
4	*Kalkai*	3.96	4.84	20.02	5.57	6.39	88.91
5	*Haldota*	2.87	7.62	23.76	3.94	9.74	68.00
6	*Nandgar*	3.63	4.87	24.47	5.19	6.98	93.60
7	*Ananth bhatta*	3.17	7.26	53.79	4.12	9.52	121.22
8	*Purappe mane*	3.92	5.10	26.20	6.40	8.25	154.00
9	*Kadigai*	8.22	10.4	348.26	8.22	10.4	348.2
10	*Karolla*	8.26	9.35	286.13	8.26	9.35	286.13
11	*Mudgar kosgai*	5.54	6.43	108.43	5.54	6.43	108.43
12	*Gadehalli kuchagai*	5.07	6.30	78.26	5.07	6.30	78.26

Morphological characterization is the first step that should be done before more profound biochemical or molecular studies are carried out (Hoogendijk and Williams, 2001). Historically mango genotypes have been characterized using morphological markers (Singh, 1969; Vasugi *et al*., 2012).The strength of the descriptors lays in its ability to delineate genotypes without redundancy. It is shown in the present study that of 12 varieties of aromatic pickle mango could be delineated adopting a set of fruit traits (Fig.1). The simple forking method adapted to individual varieties was designed in a way that traits where unambiguous categories could be made were considered first and subjective traits were considered towards the end. Such a pattern of varietal identification has not been reported for any of tree species even though morphological characterization has been done in case of *Populus* spp. (Mohanty and Khurana, 2003) and *Santalum album* (Bagchi and Veerendra, 1985). Leaf descriptors were earlier adopted to describe inter-provenancial (Rawat *et al*., 1998) or to describe inter-clonal variation (Gunaga and Surendran, 2002) in teak. Gunaga and Surendran (2002) stressed the importance of morphological characterization as a cheaper tool for quick identification of clones based on their observation of eight leaf characters. Adopting these morphological markers, it is easy to delineate the farmers' varieties both at the nursery level and at adult tree level. These descriptors are also helpful in varietal registration processes. Further, at the field level, morphological characterization offers much scope to ascertain the fidelity of varieties and help in roughing operations.

Acknowledgements

This study is the output of the UNEP/GEF supported regional project "Conservation and Sustainable Use of Cultivated and Wild Tropical Fruit Diversity: Promoting Sustainable Livelihoods, Food Security and Ecosystem Services", implemented in India, Indonesia, Malaysia, Thailand. The project is coordinated regionally by Bioversity International in collaboration with Indian Council of Agricultural Research (ICAR), New Delhi; Indonesian Centre for Horticulture Research and Development (ICHORD), Jakarta; Malaysian Agricultural Research and Development Institute (MARDI), Kuala

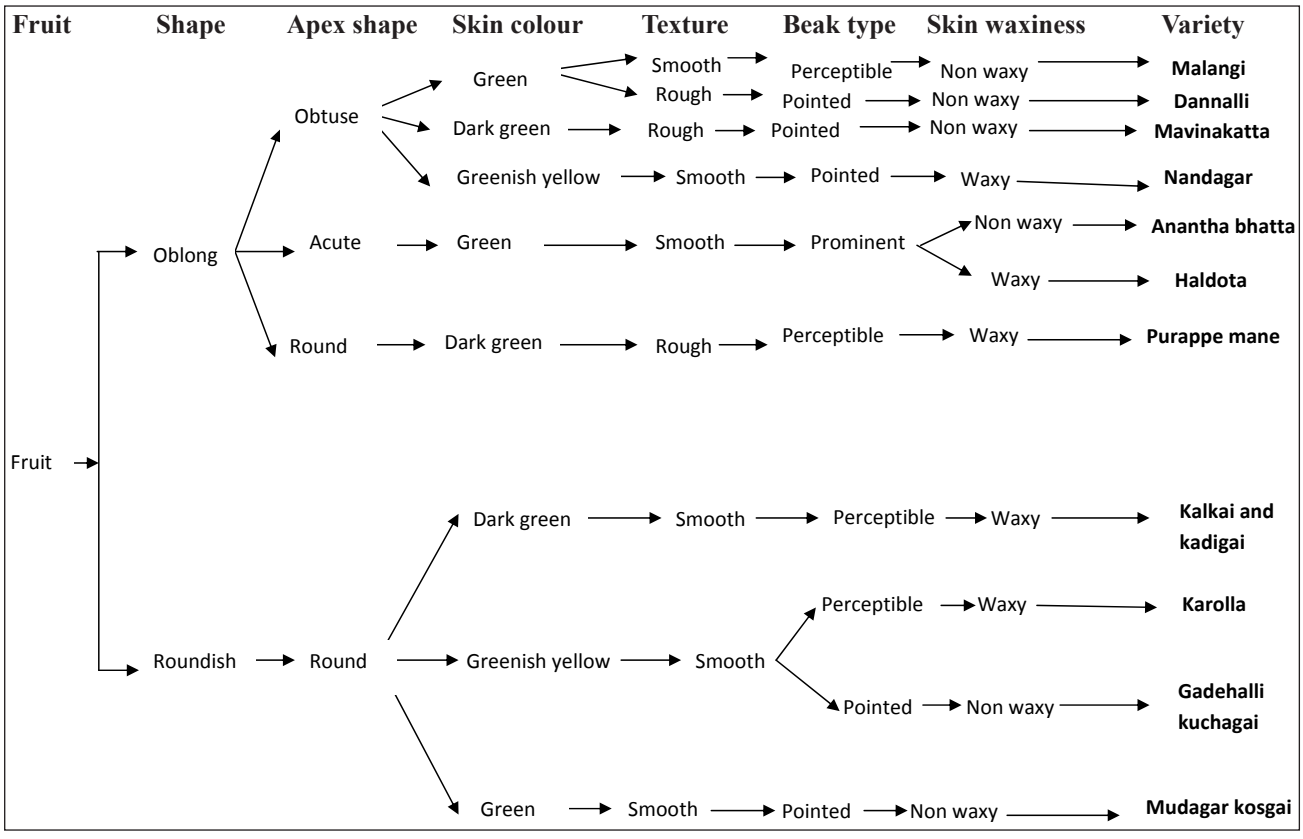

Fig. 1. Fruit-descriptors based key for the delineation of wild pickling mango varieties of the Central Western Ghats

Lumpur; Department of Agriculture (DOA), Bangkok. We profusely thank Sri Dattatreya Hegde, Salkani for kind consent and cooperation.

References

Bagchi SK and HGS Veerendra (1985) Study on intra tree and inter tree variation in leaves of *Santalum album* Linn. *Myforest* **21**: 33-39.

Bhat V, T Abebe, R Vasudeva, GV Nayak, MR Dinesh, S Rajan, B Sthapit and Ramanatha Rao (2013) Status and diversity of aromatic wild pickle mango *(Appemidi)* in home gardens and farmlands of central Western Ghats. Technical unpublished report UASD, GEF/Bioversity, ICAR.

Gautam PL, Ajay Kumar Singh, Manoj Srivastava and PK Singh (2012) Protection of plant varieties and farmers' rights: a review. *Indian J. Plant Genet. Resour.* **25**: 9-30.

Gunaga R and T Surendran (2002) Leaf morphological variation in teak (*Tectona grandis* L.f.*)* clones. *Evergreen* **48**: 8-9.

Hoogendijk M and D Williams (2001) Characterizing the genetic diversity of home garden crops: Some examples from Americas. *2nd International Home Gardens Workshop, July 17-19,2001*, Witzenhausen, Federal Republic of Germany. pp 34-40.

IPGRI (2006) Descriptors for Mango (*Mangifera indica* L.). International Plant Genetic Resources Institute, Rome, Italy, pp 36-44.

Lyngdoh Nicolee, Rajesh P Gunaga and R Vasudeva (2007) Delineation of teak (*Tectona grandis* Linn. F.) clones through leaf descriptors. *Indian J. For.* **30**: 21-28.

Mohanty TL and DK Khurana (2003) Morphological analysis of selected clones of *Populous ciliate* × *Populus maximowiczii* hybrid. *Indian J. For.* **26**: 83-89.

Mukherjee SK (1985) Systematic and eco-geographic studies on crop genepools in *Mangifera* L. IPGRI, Rome, 86 p.

Rawat MS, DP Uniyal and SL Sharma (1998) Identification of provenances based on leaf morphology in *Tectona grandis*. *Ind. For.* **124**: 248-251.

Singh LB (1969) Mango. In: Ferwerda FP & Wit F (eds) *Outlines of Perennial Crop Breeding in the Tropics*. Veenman and Zonem, Wageningen, Netherlands, 309 p.

Sthapit BR, H Lamers and VR Rao (2013) *Custodian Farmers of Agricultural Biodiversity: Selected profiles from South and South East Asia*. Proceedings of the Workshop on Custodian Farmers of Agricultural Biodiversity, 11-12 February 2013, New Delhi, India.

Vasudeva R and N Rajeshwari (2014) *Appemidi*: W*ild Aromatic Pickle Mango of the Central Western Ghats. India*. Information Brochure, UNEP/GEF project on Tropical Fruit Trees.

Vasudeva R, TA Abebe, NR Hegde and GS Deepa (2011) Documenting fruit trait diversity of aromatic pickle mango in the humid tropics of central Western Ghats. *In*: *Proc. of 'Augmenting Production and Utilization of Mango: Biotic and Abiotic Stresses*' organized by the Society for Development of Subtropical Horticulture, Central Institute for Subtropical Horticulture (ICAR), Lucknow, Uttar Pradesh, India.

Vasugi C, MR Dinesh, K Sekar, KS Shivashankara, B Padmakar and KV Ravishankar (2012) Genetic diversity in unique indigenous mango accessions (*Appemidi*) of the Western Ghats for certain fruit characteristics. *Curr. Sci.* **103**:199-207.