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TAXONOMICAL IDENTIFICATION OF MANGO (*MANGIFERA INDICA* L.) VARIETIES USING LEAF MORPHOLOGICAL CHARACTERISTICS

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ABSTRACT

Identification of varieties is important to select suitable cultivars for promoting cultivation in different areas. Identification conventionally depends upon the flowering and fruiting phases. For trees, these reproductive stages come late in the life cycle and hence identification is usually considered difficult during the vegetative phase of a plant. Leaves, however, can be used as an important identification feature during the young stage of a plant. Using leaf morphological characters, different varieties can be identified easily during vegetative stage only prior to attaining reproductive maturity. In the present study, several macro and micro morphological characteristics of leaves were used for identification of 25 cultivated varieties of mango growing in the Horticulture Research Centre, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand. A total of fifteen leaf morphological characteristics were used for the identification of which three characters (type of leaf, phyllotaxy and vestiture) were uniform in all the varieties. Large variation was, however, observed in leaf length, width, petiole length, leaf apical process, base shape and posture. Comparatively, smaller variation was observed in leaf blade shape, apex shape, colour, margin, texture and venation. Based on the leaf characters, a taxonomic identification key has been proposed here that can be used for making the identification process faster, eventually reducing the time for improvement of a cultivar.

Key words : Leaf, Identification, Taxonomic keys, Mango, Venation, Leaf posture.

Introduction

Mangifera indica L. is a member of the genus *Mangifera* belonging to the family Anacardiaceae R.Br. in the order Sapindales. It is a 15-35 meters tall, high evergreen fruit tree species of tropics and subtropics (Bhamini *et al*., 2018). Southeast Asia forms the centre of origin and diversity of the genus *Mangifera* (Yadav and Singh, 2017). Mango is so much relished in India that it is often called the 'king of fruits'. Although, India is the largest producer of mangoes with 46.02% of the total world area under mango and production of 45.88% respectively but the productivity of mango is low (Ravi *et al*., 2021; Joshi *et al*., 2012). For this reason, continuous efforts are made by horticulturists to develop improved varieties for different regions that are high yielding as well as resistant to different biotic and abiotic stresses. Proper identification and selection of suitable varieties is important for the success of varietal improvement programmes.

Mango is a perennial tree having a long juvenile period of 7-10 years. Identification of mango variety during the vegetative stage is a bit difficult (Joshi *et al*., 2013). To make the identification process simpler and authentic at an early stage, the vegetative characters of leaf can, however, be used. Mango bears simple, clustered, alternate tristichous and petiolate leaves. Leaf structure generally does not change with age except its size and colour. Leaves thus form comparatively easily available

and reliable taxonomic character that can be used for identification of mango varieties. The present study was, thus, conducted to explore the variation in leaf morphology of 25 different varieties of mango (*Mangifera indica* L.) growing in Pantnagar area for developing a leaf-based identification key that can be used for identification and selection of suitable varieties during vegetative phase.

Materials and Methods

Leaf samples of 25 varieties of mango were collected from the Horticulture Research Centre, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand during the month of September, 2023. From each variety, 2-3 trees were used for collecting the leaf samples. Observations regarding the type of leaf, phyllotaxy and posture of leaf were taken in the field. Leaf samples were later on brought to the Plant Systematics laboratory and data such as leaf length, width and petiole length were measured on the graph paper pasted on a cardboard. The leaf vestiture, texture and venation were observed under a dissecting microscope (Olympus). Processing of leaf specimens was done following standard taxonomic procedures (Jain and Rao, 1976) and samples were submitted to the herbarium of Department of Biological Sciences, Govind Ballabh Pant University of Agriculture and Technology Pantnagar, Uttarakhand, India.

Leaf morphological characters

A branch of leaf with 6-8 leaves was cut from which three intact mature leaves were used for the measurement. The morphological characters of leaves were studied using available plant systematic literature [Simpson, 2010; Singh, 2010; IPGRI (International Plant Genetic Resource Institute), 2006].

Leaf length and width

The length of each leaf was measured from leaf apex to petiole base(cm) using scaled graph paper. The width of the leaf (cm) was measured from the broadest area of the leaf.

Leaf shape and petiole length

Blade shape was determined by calculating the ratio of leaf length and width. The petiole length (cm) was measured from the leaf base to the node on the branch.

Leaf apical process, apex and base shape

Leaf apical processes were determined by observing the extension of midvein and by measuring its length: width ratio. Apex and base shape were determined by measuring the angles with the help of a protractor.

Leaf margin and posture

The margin was determined by observing the edges of the leaf. The posture of the leaf is determined by observing the placement of the leaf to its flat plane.

Leaf texture and venation

The texture of the leaf was estimated by touching the surface of leaf. The venation of the leaf was determined according to the detailed classification system of venation given by Hickey and Wolf (1975). This system is based on the pattern of primary, secondary and tertiary venation.

Results and Discussion

Leaf length, leaf width and petiole length

Leaves serve as an important plant structure for plant identification (Krishen, 2013; Ingalhalikar, 2020). The leaf shows important morphological features such as leaf posture, margins, shape, leaf apex, base and leaf surface structures *i.e.*, vestiture, texture and venation etc. that can be used for identification of different varieties and cultivars. During the present study, all these leaf-based characters of different varieties of mango were thoroughly studied. Large variation was seen among the different varieties of mango in relation to leaf length (17.5±1.8-35.0±3.5 cm), leaf width (3.5±0.3- 9.5±0.3cm) and petiole length (1.75 ±0.2 – 6.0±0.7cm) (Fig. 1). Alphonso and Pant Sinduri varieties of mango showed the maximum leaf length (35.0±3.5 and 31.0±0.7 cm respectively) and leaf width (9.5±0.3 and 8.5±0.3cm, respectively). Likewise, maximum petiole length was also observed in Pant Sindhuri (6.5±0.3cm) and Alphonso (6.0±0.7 cm). Langra showed the shortest leaf length (17.5 cm) followed by Nileshwari, Arka Uday and Alfzali. Minimum leaf width was recorded in Amrapali and Nileshwari (3.5cm) and shortest petiole length was recorded in Totapuri, Arka Uday, Neelphonso, Nileshwari and Reliance varieties. Joshi *et al*. (2012), used leaf length-width ratio along with bark and canopy spread for differentiating nine cultivars of mango growing in Pantnagar.

Thus, based on the leaf length, the different varieties of mango can be grouped into four groups- short length (15-20 cm.), sub intermediate (21-25 cm), intermediate (26-30 cm) and long length category (31-35 cm) (Fig. 2). Most of the varieties (44%) belonged to the sub-intermediate category followed by the short length category (36%). Likewise, on the basis of leaf width and petiole length, the different varieties can be grouped into three classes. Of all the studied varieties, 60% belonged to narrow width category (3-4 cm) followed by medium width varieties (32%). Similarly, 48% of varieties showed intermediate petiole length followed by short petiole length varieties (44%).

Table 1 : Leaf blade shape, apex and base shape of mango varieties.

S. no.	Mango cultivars	Leaf blade shape	Leaf apex	Leaf base
1.	Alfzali	Lanceolate	Acute with aristate process	Rounded
2.	Amrapali	Lanceolate	Narrowly acute	Cuneate
3.	Alphonso	Narrowly elliptic (1:4)	Acute apex with cuspidate apical process	Cuneate
4.	Ambika	Narrowly elliptic (1:4)	Acuminate to narrowly acute	Narrowly cuneate
5.	Arka Uday	Narrowly elliptic	Narrowly acute with aristate process	Cuneate
6.	Bombay Green	Narrowly elliptic to lanceovate	Acute apex with cuspidate apical process	Cuneate
7.	Chausa	Lanceolate to lanceovate	Acuminate	Cuneate to obtuse to oblique
8.	Dashehari	Lanceolate	Acuminate	Narrowly cuneate
9.	Konkan Ruchi	Narrowly oblong to Narrowly elliptic	Acute	Cuneate to slightly oblique
10.	Langra	Lanceolate	Narrowly acute	Narrowly cuneate
11.	Mahmoodh Bahar	Falcate to Narrowly elliptic (1:4)	Acuminate	Narrowly cuneate
12.	Mallika	Narrowly elliptic (1:5)	Narrowly acute	Narrowly cuneate
13.	Neelphonso	Narrowly elliptic (1:4)	Narrowly acute	Narrowly cuneate
14.	Nileshwari	Narrowly elliptic	Narrowly acute	Narrowly cuneate
15.	Pant Sinduri	Lanceolate to narrowly elliptic	Acute with cirrhose apical process	Cuneate
16.	Pant Chandra	Narrowly elliptic (1:5)	Narrowly acute with apiculate process	Cuneate
17.	Pusa Lalima	Narrowly elliptic (1:4)	Acute	Oblique to cuneate
18.	Pusa Pratibha	Narrowly elliptic (1:4)	Acuminate	Cuneate
19.	Pusa Shrestha	Narrowly elliptic (1:3)	Acuminate	Narrowly cuneate
20.	Ramkela	Falcate	Narrowly acute	Narrowly cuneate to oblique
21.	Reliance	Narrowly elliptic (1:5)	Narrowly acute	Narrowly cuneate
22.	Ratna	Narrowly elliptic (1:4)	Narrowly acute	Cuneate
23.	Sindhu	Narrowly elliptic (1:4)	Narrowly acute with aristate process	Cuneate
24.	Sunder Langra	Narrowly elliptic (1:4)	Acute with apiculate apical process	Oblique to cuneate
25.	Totapuri	Lanceolate	Acute with cuspidate	Cuneate to rounded

Leaf blade shape, apex, apical processes and base shape

Most of the varieties, in the present study, were narrowly elliptic and lanceolate in leaf shape whereas Ramkela variety showed falcate blade shape (Table 1). The mango varieties showed acute, acuminate and narrowly acute leaf apex showing cirrhose, cuspidate, aristate and apiculate leaf apical processes. A good number of mango varieties showed acute to narrowly acute apex shape with aristate apical process. Varieties like Chausa, Dashehari, Pusa Pratibha, Pusa Shrestha showed acuminate apex shape with no apical process. Five types of base shapes (narrowly cuneate, cuneate, obtuse, rounded and oblique) have been observed in different varieties. Most of the varieties showed cuneate to narrowly cuneate leaf base shape, except Ramkela and Alfjali where leaves showed oblique and rounded base shape, respectively (Fig. 3).

Leaf colour, margin, texture, venation and posture

Table 2 represents the variation in leaf colour, margin,

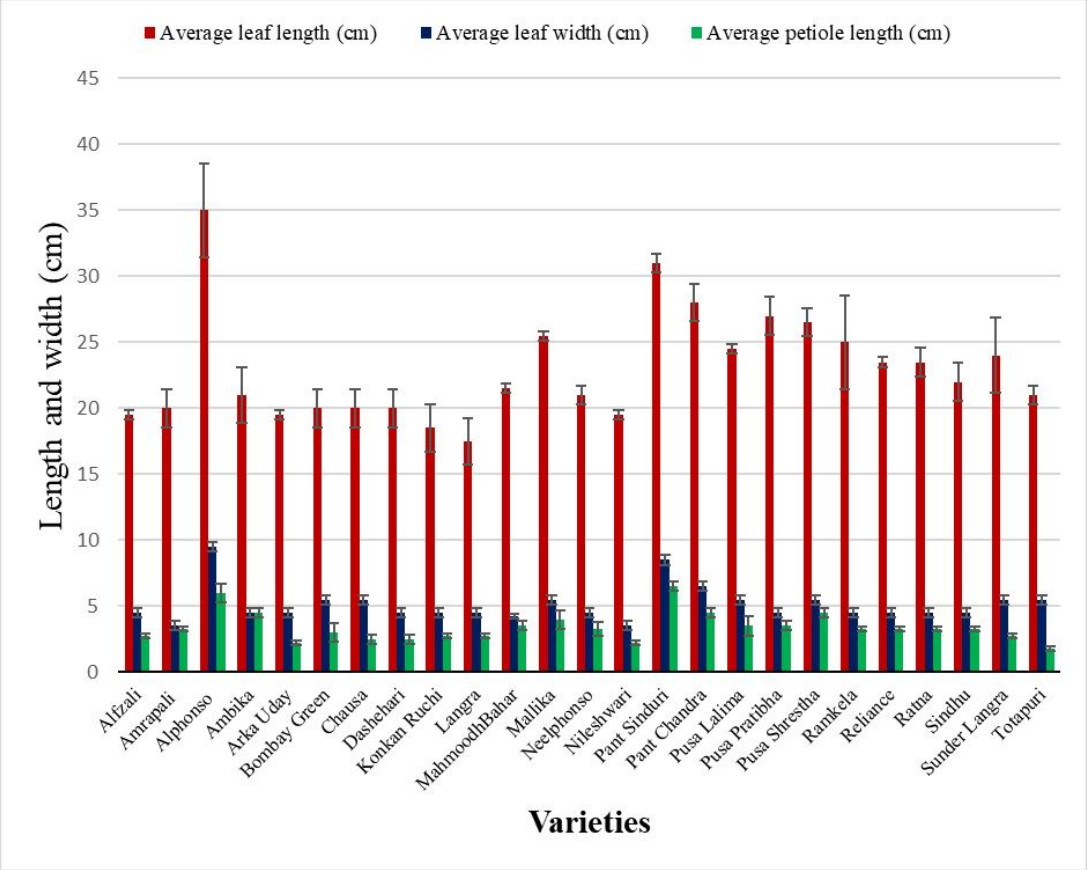

Fig. 1 : Leaf length, leaf width and petiole length of 25 mango varieties with standard error.

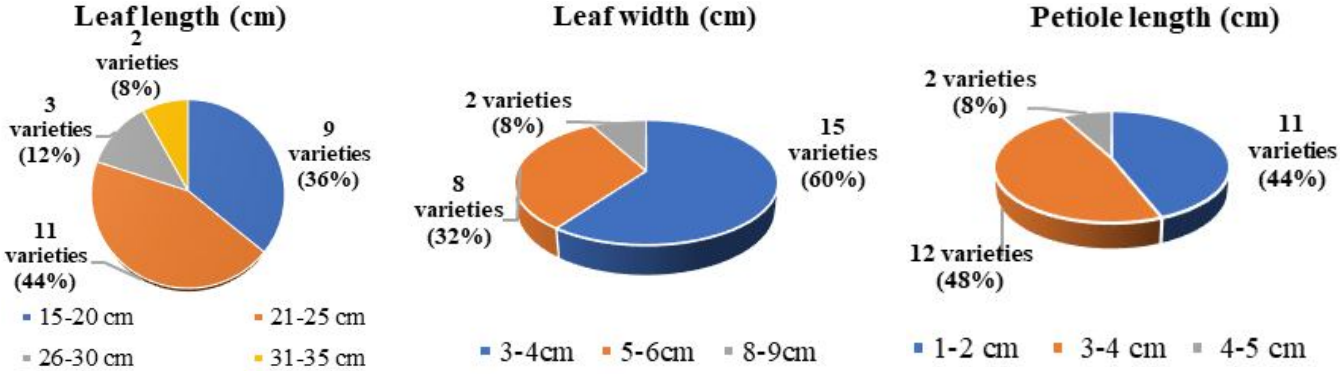

Fig. 2 : Number of varieties expressed as different groups on the basis of difference in leaf length, width and petiole length.

texture, posture and leaf venation of the mango varieties. Two types of leaf margins (entire and undulate) and leaf textures (coriaceous and chartaceous) have been observed across the different varieties. All the varieties showed coriaceous leaf texture except Alphonso that showed chartaceous texture. Similarly, the leaf posture showed a unique pattern which can be used as a distinct feature to identify mango varieties easily during vegetative phase. Involute, revolute, flat and conduplicate types of leaf postures were observed in the present study. Conduplicate, involute and flat type leaf postures were observed in eight varieties. Only one variety, Neelphonso, showed involute posture with revolute apex posture. Likewise, most of the mango cultivars showed dark green adaxial and light green abaxial leaf surfaces. A few cultivars like Alphonso, Ambika, Chausa, Lungra, Mallika, Neelphanso, Pant Chandra and Sunder Lungra showed dark green colour at both the surfaces; Konkan Ruchi, however, showed both the leaf surfaces light green in colour. Similarly, most of the cultivars exhibited pinnately, simple craspedodromous type of reticulate leaf venation, however, Chausa and Dashehari showed pinnately brochidodromous reticulate venation. Amrapali and Bombay Green showed eucamptodromous reticulate

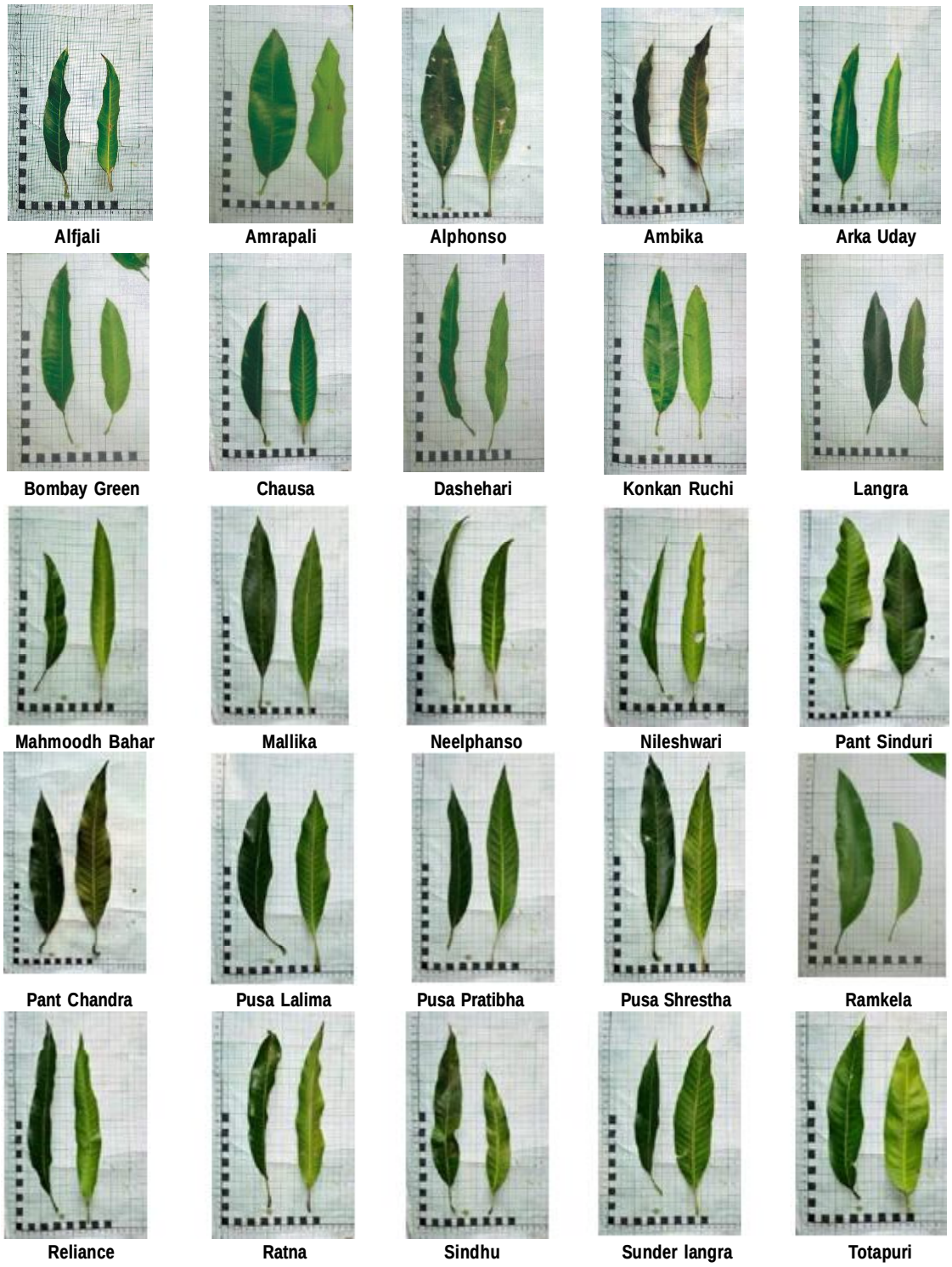

Fig. 3 : Leaves of different mango varieties.

venation in the upper part and simple craspedodromous venation in the lower part of the leaf.

Similar to the present study, Rymbai *et al.* (2014), used leaf morphological traits along with several physiological characters (gas exchange traits, epicuticular wax, light harvesting pigments) for differentiating eight different mango cultivars grown in different agro-ecological regions of India. According to Mohamed *et al*. (2015), the variation across different cultivars depends upon the genotype of individual cultivars and the prevailing cultural practices. Rai *et al*. (2023) observed wide variability in leaf apex shape, base shape, blade shape, leaf colour and flowering behaviour of 25 mango genotypes. Ruchika *et al.* (2023) documented germplasm

Table 2 : Leaf colour, margin, texture, leaf posture and venation of mango varieties.

S. no.	Mango cultivars	Leaf colour	Leaf margin	Leaf texture	Leaf posture	Leaf venation
1.	**Alfzali**	Dark green adaxial surface light green abaxial surface	Entire and undulate	Coriaceous	Conduplicate with two arches at one side	Simple craspedodromous
2.	**Amrapali**	Dark green adaxial surface light green abaxial surface	Undulate	Coriaceous	Involute	Eucamptodromous and simple craspedodromous at base of leaf
3.	**Alphonso**	Both surfaces dark green	Entire	Chartaceous	Flat	Simple craspedodromous
4.	**Ambika**	Both surfaces dark green	Undulate	Coriaceous	Conduplicate	Simple craspedodromous
5.	**Arka Uday**	Dark green adaxial surfacelight green abaxial surface	Entire	Coriaceous	Involute at upper side	Simple craspedodromous
6.	**Bombay Green**	Dark green adaxial surfacelight green abaxial surface	Undulate	Coriaceous	Involute	Pinnately eucamptodromous at upper part Simple craspedodromous at lower part
7.	**Chausa**	Both surfaces dark green	Entire to undulate	Coriaceous	Involute	Camptodromous, brochidodromous
8.	**Dashehari**	Dark green adaxial surfacelight green abaxial surface	Undulate to entire	Coriaceous	Conduplicate	Camptodromous, brochidodromous
9.	**Konkan Ruchi**	Both surfaceslight green	Entire	Coriaceous	Flat	Simple craspedodromous
10.	**Langra**	Both surfaces dark green	Entire	Coriaceous	Involute	Simple craspedodromous
11.	**Mahmoodh Bahar**	Both surfaces dark green	Entire	Coriaceous	Conduplicate	Simple craspedodromous
12.	**Mallika**	Both surfaces dark green	Entire	Coriaceous	Conduplicate	Simple craspedodromous
13.	**Neelphanso**	Both surfaces dark green	Entire	Coriaceous	Involute and revolute apex	Simple craspedodromous
14.	**Nileshwari**	Dark green adaxial surfacelight green abaxial surface	Entire	Coriaceous	Conduplicate	Simple craspedodromous
15.	**Pant Sinduri**	Dark green adaxial surface light green abaxial surface	Entire and undulate	Coriaceous	Involute	Simple craspedodromous
16.	**Pant Chandra**	Both surfaces dark green	Entire to undulate	Coriaceous	Flat	Simple craspedodromous
17.	**Pusa Lalima**	Both surfaces dark green	Entire	Coriaceous	Slightly involute	Simple craspedodromous
18.	**Pusa Pratibha**	Dark green adaxial surfacelight green abaxial surface	Entire	Coriaceous	Flat	Simple craspedodromous
19.	**Pusa Shrestha**	Dark green adaxial Surfacelight green abaxial surface	Entire	Coriaceous	Flat to involute	Simple craspedodromous
20.	**Ramkela**	Dark green adaxial surfacelight green abaxial surface	Entire and undulate	Coriaceous	Flat	Pinnately simple craspedodromous
21.	**Reliance**	Dark green adaxial surfacelight green abaxial surface	Entire and undulate	Coriaceous	Slightly conduplicate	Simple craspedodromous
22.	**Ratna**	Dark green adaxial surfacelight green abaxial surface	Undulate	Coriaceous	Involute to conduplicate	Simple craspedodromous
23.	**Sindhu**	Dark green adaxial surface light green abaxial surface	Undulate	Coriaceous	Flat	Simple craspedodromous
24.	**Sunder Langra**	Both surfaces dark green	Entire	Coriaceous	Flat	Simple craspedodromous
25.	**Totapuri**	Dark green adaxial surface light green abaxial surface	Entire and undulate	Coriaceous	Flat	Simple craspedodromous

Table 3 : Taxonomic keys for the 25 mango varieties.

1a	Leaf texture chartaceous	Alphonso
1b	Leaf texture coriaceous	2
2a	Leaf margin undulate	3
2b	Leaf margin entire	13
3a	Leaf colour dark green at both surfaces	4
3b	Leaf dark green on adaxial side light green on abaxial side	6
4a	Leaf apex acuminate	Chausa
4b	Leaf apex narrowly acute	5
5a	Leaf posture conduplicate	Ambika
5b	Leaf posture flat	Pant Chandra
6a	Leaf apex narrowly acute	7
6b	Leaf apex acute	11
7a	Venation pinnately eucampto-dodromous	Amrapali
7b	Venation pinnately simple craspedodromous	8
8a	Leaf shape falcate	Ramkela
8b	Leaf shape narrowly elliptic	9
9a	Leaf posture flat	Sindhu
9b	Leaf posture conduplicate	10
10a	Leaf base narrowly cuneate	Reliance
10b	Leaf base cuneate	Ratna
11a	Venation pinnately eucampto-dromous at upper part simple craspedodromous at lower part	Bombay Green
11b	Venation simple craspedo-dromous in entire leaf	12
12a	Leaf shape lanceolate	Totapuri
12b	Leaf shape narrowly elliptic	Pant Sindhuri
13a	Venation pinnately brochido-dromous	Dashehari
13b	Venation pinnately simple craspedodromous	14
14a	Leaf shape lanceolate	15
14b	Leaf shape narrowly elliptic	16
15a	Leaf apex acute	Alfjali
15b	Leaf apex narrowly acute	Langra
16a	Leaf base narrowly cuneate	17
16b	Leaf base cuneate	21
17a	Leaf dark green on adaxial surface light green on abaxial surface	18
17b	Leaf dark green on both sides	19
18a	Leaf posture conduplicate	Nileshwari
18b	Leaf posture involute	Pusa Shrestha
19a	Leaf posture revolute	Neelphanso
19b	Leaf posture conduplicate	20
20a	Leaf apex acuminate	Mahmood Bahar
20b	Leaf apex narrowly acute	Mallika
21a	Leaf posture involute	22
21b	Leaf posture flat	23
22a	Dark green adaxial, light green abaxial leaf	Arka Uday
22b	Leaf dark green at both side	Pusa Lalima
23a	Leaf apex acuminate	Pusa Pratibha
23b	Leaf apex acute	24
24a	Leaf colour light green both sides	Konkan Ruchi
24b	Leaf colour dark green both sides	Sunder Langra

Table 3 continued....

Table 3 continued....

variability of wild mango in coastal districts of Karnataka using three foliage characters (*viz.*, leaf blade length, blade width and petiole length) and eleven fruit characters.

The present study, however, focussed on twelve macro and micromorphological traits of leaf for identification of different varieties. Based on these leaf morphological characteristics, a dichotomous taxonomic key has been generated for easy and rapid identification of the different varieties (Table 3). This key will help to identify the different varieties simply by comparing a few important morphological features of the mango leaves which are available during the juvenile as well as mature phase of the plant.

Conclusion

This research shows the comparison of 25 varieties of mango based on morphological characters of leaves. Out of 15 different leaf morphological characters, only three characteristics *i.e.*, type of leaf (simple leaf), phyllotaxy (alternate tristichous) and vestiture (glabrous) of leaves are common to all the varieties. A large variation is present in leaf length, leaf width, petiole length, leaf apical process, leaf base shape and leaf posture compared to characters like leaf blade shape and apex shape etc. The macro and micromorphological characters of leaves can be effectively utilized for identification of different varieties of mango during vegetative stage. It will eventually help the farmers and mango breeders for an

early and easy identification of suitable varieties for promoting their cultivation and making use of these varieties for crop improvement programmes.

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