



Leaf morphological variations among Betel vine (*Piper betle* L.) cultivars of Kerala

P Aswathi¹, A R Sivu², N S Pradeep³, D K Sathish¹

¹ Research Department of Botany, University College, Thiruvananthapuram, Kerala, India

² Research Department of Botany, Mahatma Gandhi College, Thiruvananthapuram, Kerala, India

³ Malabar Botanical Garden and Institute for Plant Sciences, Kozhikode, Kerala, India

Abstract

The present study compares leaf morphological variations among twenty cultivars of betel from Kerala. There are over 100 different types of betel cultivars in the world and depending upon the area of cultivation they show variation in taste and smell. Morphological study revealed significant differences among the cultivars in both qualitative (Colour of lamina, leaf apex shape, lamina orientation along the midrib etc) and quantitative characters (leaf length, width, Length of petiole, depth of sinus, width of lobe, etc.). The comparative morphological assessment cultivars revealed that *Karpooram*, *Selan* and *Thulasi*, show remarkable similarity among them compare to that of the rest of cultivars.

Keywords: *Piper betle*, piperaceae, cultivars, morphology, Kerala

Introduction

Piper betle L., a member of *Piperaceae* family is an indigenous medicinal and cash crop of India. Glabrous dark green heart shaped leaves of plant have high medicinal, commercial and economical value and have a reputed position in folklore medicine of Latin America and West Indies and in Indian Ayurvedic system of medicine (Parmar *et al.*, 1997) [17]. Ancient Indian literature mentioned this crop as early as AD 473 (Sing 1994) [19]. Betel leaves commonly known as paan in India in *apabhransa* of Sanskrit *paan* means leaf. From the dawn of civilization betel leaf has held a prestigious role in human culture. According to Guha (2006) [1] 15-20 million individuals in the country consume betel leaves on daily basis. It is grown on 45,000 hectares and generates a revenue of 9000 million per year Betel leaves commonly known as paan in India in *apabhransa* of Sanskrit *paan* means leaf. It also known as *Nagaballi*, *Nagini*, *Nagavallari*, *Mukhbhushan*, *Varnalatha*, *Nagurvel*, *Sapthasira*, *Somapatra*, *Tamalapaku*, *Tambul*, *Tambuli*, *Vaksha Patra*, *Vettilai*, *Voojagalata* etc in different parts of the country (Guha and Jain, 1997) [2]. Frequent references to *thambool* can see in several ancient Sanskrit texts like *Charakasamhitha* and *susruthasamhitha*, *Ashtanga Hridayam*, *Bhavaprakasa*, *Harivamsa*, *Varahapurana*, *Panchathanthra* and *Jathaka tiles*. Native place of *Piper* is Central and Eastern Malaysia (Guha., 2006.) [1] and was introduced throughout Tropical Asia, Betel vine farming estimated to cover 8 % of the world's land area. India, China, Indonesia, Sri Lanka, Malaysia, Nepal, South Africa, Philippines, Burma, Pakistan, Bangladesh, and Papua New Guinea are the primary betel vine-growing nations (Samanta, 1994) [3]. It is assumed that betel vine was introduced by Arab and Chinese merchants introduced betel vine to Sri Lanka and other South Asian countries (Department of Export Agriculture, Sri Lanka, 2012). Around 1000 varieties of betel leaves present in the world, out of which around 150 cultivars found in India and 30 in West Bengal (Guha and Jain., 1997; Samanta., 1994) [2, 3]. There are more than 2 billion consumers of betel vine all over the world and in India 15-20 million people consume betel leaves in a regular basis. The leaves used for both domestic consumption and for export to European countries, USA, Myanmar, Pakistan. The most popular betel leaves being *Calcutta*, *Magahi* and *Banarasi*. In rural Bangladesh major source of income comes from pan cultivation. In Kerala, the most famous variety of betel leaf is *Venmany vettila* from Venmany near Chengannur. Betel leaf from Hinjicut in Odisha and *Tirur pann* from Kerala are of fine quality. Betel leaves cultivated in Tirur are famous in Pakistan as "*Tirurpaan*". In Tamil Nadu a variety of betel leaves are cultivated at Madhuri, Dindukal, Dharmapuri and Erode district. *Anthiyur betel* from Tamil Nadu is popular among betel chewers. A large number of farmers and other employees are involved both directly and indirectly in betel leaf cultivation and marketing. In India, traders and cultivators recognized between 125-150 cultivars of betel vine (Verma *et al.*, 2004; Ranade *et al.*, 2002) [4, 5], with majority of them were known by the name of the region where they were grown *Salem*, *Magadhi*, *Banarasi*, *Calcutta*, *Kauri*, *Hanagete*, *Bagerhati*, *Venmony* and *Mysore* are some of the most well known Indian cultivars (Manoj *et al.*, 2011). After the evaluation of seven betel vine cultivars in West Bengal Ranade *et al* 2002 [5], noticed that cultivar *Kapoori* were more heterogenous, whereas *Bangla* cultivars were mainly identical. Sheet (2002) found that cultivar named *Chandrakona* was superior to the other cultivars in most of the features. In India mal plants are often planted for the purpose of obtaining green leaves (Lakshmi and Naidu., 2010) [7]. Andhra Pradesh, Assam, Bihar, Madhya Pradesh, Maharashtra, Karnataka, Kerala, Orissa, Tamil Nadu, Uttar

Pradesh and West Bengal are among the states where betel vines are grown (Sugumaran *et al.*, 2011). The best betel leaf was supposed to be the *Maghai* type (which means “from the Magadha area”) which was grown near Patna in Bihar (Rani and Ramamurthy, 2012). According to Senguptha (2014) ^[9], Maghai is one of India’s most common betel vine varieties. Since this crop is cultivated widely, it is claimed to have hundreds of varieties which can be broadly grouped into six major types such as *Bangla*, *Desavari*, *Kapoori*, *Sanchi*, *Meetha* and *Kasi* (Rawath and Balasubramanyam., 1984) ^[10]. These varieties cater to a very wide range of organoleptic preferences of the users. The leaves vary in taste from a very pungent to mild and even sweet as in the case of *meetha* which grows in a very small region of Bengal *Pozhikodi*, *Nadankodi* and *Thulasivettila*. are the three cultivars identified by Abraham (1986) ^[12]. Joseph in 1990 ^[11] investigated 42 taxa including *Betel var. Aluva* from Kizhakambalam, *var. Nadankodi* from Calicut, *Var. Salem* from Salem, *Var. Thekkankodi* from Idukki, *var. Thulasikodi* from Thevera. *Cheelanthikarpooram* is the most common betel vine in Thiruvananthapuram. *Venmany vettila* from Venmany near Chengannur is a well-known cultivar in Kerala. The most prevalent cultivars of Kerala *Venmony*, *Arikodi*, *Kalkodi*, *Karilanchi*, *Nadankodi*, *Karpooram*, *Kootakodi* *Kodinandal*, *Amaravila*, *Cheenthikarpooram*, *cheelanthivella*, *cheelanthi chevala*, and *pramuttan* (Preethy *et al.*, 2016) ^[13]. Many of these are land races specific to different regions of Kerala rather than the district varieties. The present study is an attempt to characterize the betel vine cultivars at the molecular level in order to assess their varietal differences and uniqueness.

Materials and Methods

Collection of *Piper betel* cultivars.

Fresh materials of twenty cultivars of *P. betel* vines were collected from various areas (Table.1) of Kerala state for morphological and anatomical studies. Healthy materials were chosen with Care.

Table 1: Collection details of *Piper betel* accessions used in present study

Name of cultivars	Place of collection	Geographical coordination	Herbarium Number
<i>Aryan</i>	Vembayam	08° 64' 82.12''N, 76° 91' 79.11'' E	UCBD 0053
<i>Aruvan vella</i>	Anchal	08° 57' 08.41''N, 76° 58' 64.20'' E	UCBD 0052
<i>Chelan/Selan</i>	Thirunnavaya	10° 88' 32.81''N, 75° 99' 83.07'' E	UCBD0056
<i>Cheelanthi chevala</i>	Aruvikkara	08° 33' 77.20''N, 77° 01' 55.70'' E	UCBD 0054
<i>Cheelanthi vella</i>	Aruvikkara	08° 33' 77.21''N, 77° 01' 55.74'' E	UCBD 0055
<i>Irujathikodi</i>	Anchal	08° 56' 69.12''N, 76° 58' 35.97'' E	UCBD 0057
<i>Karilanchi</i>	Vattappara	08° 59' 40.10''N, 76° 93' 68.70'' E	UCBD 0059
<i>Karinadan</i>	Thirunnavaya	10° 88' 32.67''N, 75° 99' 82.77'' E	UCBD 0058
<i>Karpooram</i>	Amballoor	10° 45' 52.60''N, 76° 28' 31.22'' E	UCBD 0060
<i>Kootakodi</i>	Thirunnavaya	10° 88' 33.59''N, 75° 99' 83.55'' E	UCBD 0061
<i>Marakodi</i>	Amballoor	10° 45' 52.92''N, 76° 28' 31.10'' E	UCBD 0062
<i>Nadankodi</i>	Thirunnavaya	10° 88' 33.59''N, 75° 99' 83.52'' E	UCBD 0063
<i>Thaikodi</i>	Venjaramoodu	10° 40' 98.22''N, 76° 55' 47.10'' E	UCBD 0068
<i>Thulasi</i>	Venjaramoodu	08° 68' 15.68''N, 76° 91' 42.21'' E	UCBD 0069
<i>Pattanavella</i>	Anchal	08° 56' 92.50''N, 76° 58' 64.21'' E	UCBD 0065
<i>Panikarpooram</i>	Kattakada	08° 50' 96.77''N, 77° 05' 90.41'' E	UCBD 0064
<i>Pramuttan</i>	Vattappara	08° 59' 40.10''N, 76° 93' 68.70'' E	UCBD 0067
<i>Poyya</i>	Amballoor	10° 45' 52.52''N, 76° 28' 31.20'' E	UCBD 0066
<i>Vellamunda</i>	Pothencode	08° 61' 66.86''N, 76° 90' 63.35'' E	UCBD 0070
<i>Venmany</i>	Chengannur	09° 15' 73.91''N, 76° 38' 39.24'' E	UCBD 0071

The taxonomic identities of the accessions were determined using regional flora (Gamble, 1957) and their varietal names were given by those who owned the vines in their homes. The varietal names are used to indicate each accession since the nomenclature of betel vine is the widespread craze among farmers to name the varieties after their village or town. Voucher herbariums are deposited in University College Botany Department herbaria Thiruvananthapuram and the accession numbers are recorded.

Morphological Characters

Qualitative Characters

Seven qualitative characters such as Stem colour, Lamina colour, Leaf lamina orientation along the midrib, Leaf apex shape, Leaf texture, Proximity of basal lobes and number of veins were studied.

Quantitative Characters

Nine quantitative characters like Number of adventitious root, inter-nodal length, leaf length, breadth of leaf, length/breadth ratio, petiole length, depth of sinus (total length-length from midrib), lobe width, depth of sinus/width of lobe ratios were investigated from five harvestable leaf from five different vines of each cultivars picked at random.

Results and Discussion

20 cultivars from different regions of Kerala were studied (Plate 1-3). For the comparative assessment of morphological diversity between the cultivars, seven qualitative characters (Table. 2) and nine quantitative characters (Table.3) were studied. From the comparative morphological assessment cultivars -*Karpooram*, *Selan* and *Thulasi*, show remarkable similarity among them compare to that of the rest of cultivars. They have some common features like light green stem, yellow lamina, V-shaped leaf orientation and the proximity of basal lobe is separate. Leaf texture of *Selan* differs from the *Thulasi* and *Karpooram* for having membranous leaf texture is in *Selan* and coreaceous in *Thulasi* and *Karpooram*. Cultivar *Thulasi* is distinguished from other two by its acute leaf apex and brown stem colour. *Selan* and *Karpooram* on the other hand, have acuminate leaf apex and light green stem colour. All other cultivars have predominantly similar morphological characteristics. An interesting observation is that all cultivars possess some shared characteristics with one or more other cultivars. For example *Selan* has shared most of its features with that of *Karpooram* and *Thulasi* at the same time it has membranous leaf texture similar to that of *Aryan* and *Vellamunda*. Similarly *Karpooram* has several characteristics with the other cultivars, such as leaf apex shape (acuminate) and leaf texture (Coreaceous). Although the cultivars *Pattanavella*, *Aruvanvella*, *Cheelanthi chevala*, *Irujathikodi*, *Cheelanthivella* and *Marakkodi* all have nine veins but they differ in many other features. The cultivars *Karpooram* and *Thulasi* are different from the rest of the cultivars in having five numbers of veins. This shared resemblances and differences among the cultivars indicate the fact that a discrete classification is not possible based on morphological features alone. The comparative leaf morphology of north Indian cultivar of *Piper betle* showed similar observations with shared similarity and differences among the cultivars (Lakshmi and Naidu, 2010) [7].

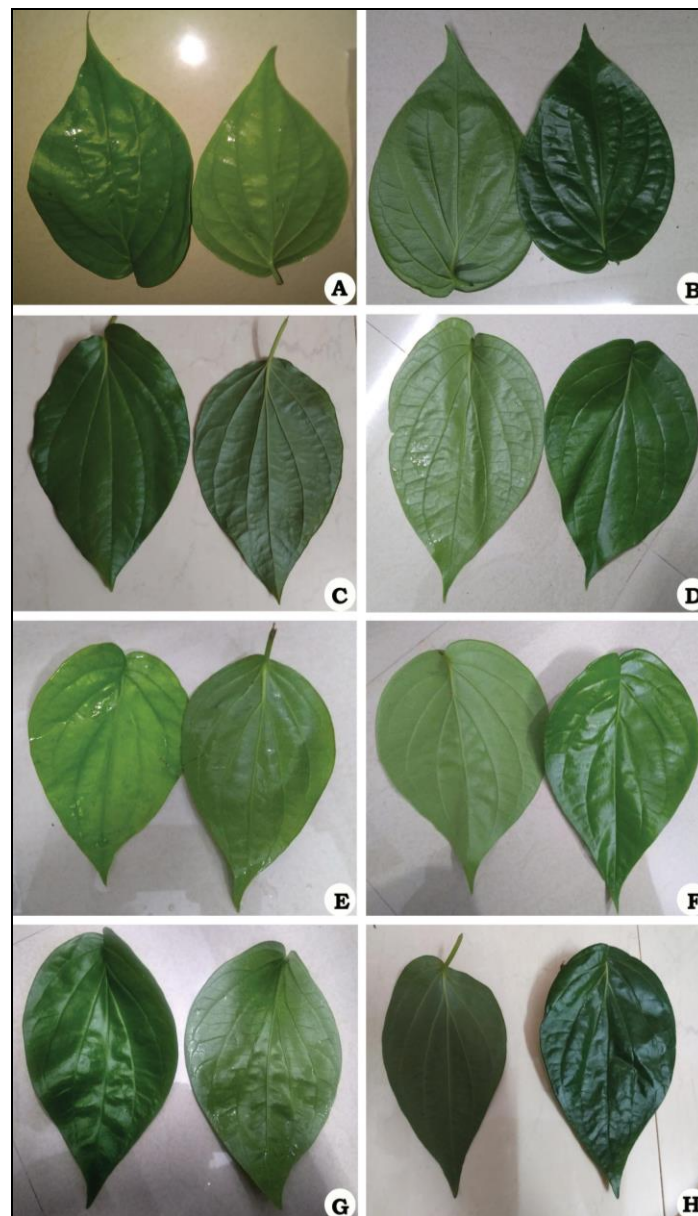


Plate 1: Dorsal and ventral view of *P. betel* leaves. A. Aryan, B. Aruvan vella C. Chelan, D. Cheelanthi Chevala, E. Cheelanthi Vella, F. Irujathi Kodi, G. Karilanchi, H. Karinadan.

Table 2: Qualitative characters of *Piper betle* cultivars

Name of Cultivar	Stem colour	Lamina colour	Leaf lamina orientation along the midrib	Leaf apex shape	Leaf texture	Proximity of basal lobes	Number of veins
<i>Aryan</i>	Green	Green	Flat lamina	Acuminate	Membranaous	overlapped	7
<i>Aruvanvella</i>	Light green	Green	Flat lamina	Acuminate	Coriaceous	overlapped	9
<i>Cheelanthi chevala</i>	Light green	Light green	Flat lamina	Acuminate	Coriaceous	overlapped	9
<i>Cheelanthi vella</i>	Green	Light green	Flat lamina	Acuminate	Coriaceous	overlapped	9
<i>Chelan/Selan</i>	Light green	Light green	V-shaped	Acuminate	Membranaceous	separate	7
<i>Irujathikodi</i>	Green	Green	Flat lamina	Acuminate	Coriaceous	overlapped	9
<i>Karilanchi</i>	Green	Green	Flat lamina	Acuminate	Coriaceous	close	7
<i>Karinadan</i>	Green	Dark green	Flat lamina	Acute	Coriaceous	overlapped	7
<i>Karpooram</i>	Light green	Yellow	V-shaped	Acuminate	Coriaceous	separate	5
<i>Kootakodi</i>	Green	Dark green	Flat lamina	Acute	Coriaceous	close	7
<i>Marakodi</i>	Green	Green	Flat lamina	Acute	Coriaceous	overlapped	9
<i>Nadankodi</i>	Green	Green	Flat lamina	Acute	Coriaceous	separate	7
<i>Panikarpooram</i>	Green	Green	Flat lamina	Acuminate	Coriaceous	overlapped	7
<i>Pattanavella</i>	Green	Light green	Flat lamina	Acuminate	Coriaceous	overlapped	9
<i>Poyya</i>	Green	Green	Flat lamina	acute	Coriaceous	separate	7
<i>Pramuttan</i>	Light green	Green	Flat lamina	Acute	Coriaceous	separate	7
<i>Thaikodi</i>	Green	Light green	Flat lamina	Acuminate	Coreaceous	overlapped	7
<i>Thulasi</i>	Brown	Yellow	V-shaped	Acute	Coriaceous	separate	5
<i>Vellamunda</i>	Green	Green	Flat lamina	Acuminate	Membranous	close	7
<i>Venmany</i>	Green	Light green	Flat lamina	Acuminate	Coriaceous	overlapped	7

Table 3: Quantitative characters of *Piper betle* cultivars

Name of Cultivar	Advantitious root	Internodal length	Length of petiole	Leaf length	Leaf Breadth	Length breadth ratio	Lobe width	Depth of sinus	depth of sinus /Width of lobe ratio
<i>Aryan</i>	5±7	8.5±11.3	2.9±3.3	17±18.5	10±12	1.4±1.8	2.8±3.9	0.8±2.1	0.43
<i>Aruvan vella</i>	11±13	10±12.4	2.2±3.1	19.5±23	13.1±15.5	1.3±1.6	4.8±5.8	1.1±2.6	0.33
<i>Cheelanthi chevala</i>	11±15	11.2±13	2.9±3.6	16.6±19.8	10.2±12.8	1.4±1.8	2.9±4	0.4±0.9	0.17
<i>Cheelanthi vella</i>	12±15	12.8±14.1	2.9±3.6	16.1±19.5	9.8±12.1	1.6±1.8	3.1±4.2	0.5±1.2	0.22
<i>Chelan/Selan</i>	7±9	7.5±10	2.1±3.2	13.8±17.8	7.5±9.9	1.7±2	1.1±3	0.4±1.1	0.41
<i>Irujathikodi</i>	6±8	6.1±7.9	2.8±3.5	18±20	13.1±16.3	1.1±1.5	4.2±5.5	0.5±1.2	0.18
<i>Karilanchi</i>	4±6	10±12.4	2.4±3.2	18.8±21.6	10.4±13.9	1.4±1.8	2.9±4.2	0.5±1.3	0.26
<i>Karinadan</i>	10±14	7.5±9.8	2.4±4	19±22.8	11.1±14.4	1.4±1.7	2.5±5.1	1.1±1.8	0.38
<i>Karpooram</i>	6±9	5.5±8.9	3±4.5	11.9±14.7	6.9±8.7	1.5±1.9	1.7±3.7	0.7±1.1	0.37
<i>Kootakodi</i>	11±14	12±13.5	2±3.8	17.8±20.5	10.2±13.6	1.4±1.9	2.4±4.3	0.5±1.3	0.28

<i>Marakodi</i>	6±9	10.8±12.5	2.9±3.9	19.1±22.5	10.1±13.2	1.5±2.1	2.9±4.1	0.5±1.5	0.29
<i>Nadankodi</i>	6±9	10.9±12.5	2.5±4.4	15.1±18.8	11.1±14.5	1.1±1.5	2.5±4	.4±1.3	0.28
<i>Panikarpooram</i>	7±9	8.9±10.1	2.9±3.6	16.4±18.5	12.5±14	1.2±1.5	2.8±4.1	0.4±2	0.35
<i>Pattanavella</i>	12±14	10.7±12.5	2.5±4.2	15.2±17.5	10.1±12.4	1.3±1.7	3.6±4.8	0.2±2.2	0.28
<i>Poyya</i>	10±13	11.9±13.6	3±3.8	15.9±18.7	12.5±13.5	1.2±1.4	3±4	0.8±2.2	0.43
<i>Pramuttan</i>	7±9	9±11.8	2.2±3.9	16±19.9	9.9±12.6	1.4±1.8	3±3.7	0.3±0.9	0.18
<i>Thikodi</i>	5±9	8.5±11	2.8±3.9	16.5±18.1	10.5±12.1	1.4±1.7	3.7±4.1	0.4±1.3	0.24
<i>Thulasi</i>	4±7	5±7.2	3±4.5	7±10	5.5±7	1.3±1.5	2.2±2.7	0.6±1.5	0.42
<i>Vellamunda</i>	6±8	12.5±13.2	2.3±3.1	17.4±20	11±13	1.3±1.8	2.4±4.3	0.9±2.1	0.37
<i>Venmany</i>	22±25	12±14.5	2±3.1	17±20	10.1±13	1.5±1.7	3.3±5	1.1±2.2	0.38

Table 4: Comparative Morphological data of Pier btele Cultivars

Name of cultivars	Number of adventitious root Few : <5 Medium: 5-10 Many : >10	Internodal length Very short: <4 Short: 4-6 Medium: 6-8 Long: >8	Length of petiole Short:<6 Medium: 6-8 Long : >8	Leaf length Very short:<7 Short:7-11.5 Medium:11.5-14.5 Long : >14.5th	Leaf Breadth Narrow: < 9.50 Medium: 9.50-2.50 Broad: > 12.50	Length breadth ratio Low: <1.30 Medium: 1.3-1.5 High: > 1.5	Lobe width Short: <3.5 Medium: 3.5-5 Long : > 5	Depth of sinus Shallow: <0.6 Medium: 0.6-1.2 Deep: > 1.2	Depth of sinus /width of lobe Slightly lobbed: < 0.15 Moderately lobbed: 15.25 Deeply lobbed: >25
<i>Aryan</i>	Medium	Long	Short	Long	Medium	High	Short	Deep	Deeply lobbed
<i>Aruvanvella</i>	Many	Long	Short	Long	Broad	Medium	Medium	Deep	Deeply lobbed
<i>Cheelanthi chevala</i>	Many	Long	Short	Long	Medium	Medium	Short	Shallow	Moderately lobbed
<i>Cheelanthi vella</i>	Many	Long	Short	Long	Medium	High	Medium	Medium	Deeply lobbed
<i>ChelanSelan</i>	Medium	Long	Short	Long	Narrow	High	Short	Medium	Deeply lobbed
<i>Irujathikodi</i>	Medium	Medium	Short	Long	Broad	Medium	Medium	Medium	Moderately lobbed
<i>Karilanchi</i>	Medium	Long	Short	Long	Broad	High	Medium	Medium	Deeply lobbed
<i>Karinadan</i>	Many	Long	Short	Long	Broad	Medium	Medium	Deep	Deeply lobbed
<i>Karpooram</i>	Medium	Medium	Short	Medium	Narrow	High	Short	Medium	Deeply lobbed
<i>Kootakodi</i>	Many	Long	Short	Long	Medium	High	Short	Medium	Deeply lobbed
<i>Marakodi</i>	Medium	Long	Short	Long	Medium	High	Short	Medium	Deeply lobbed
<i>Nadankodi</i>	Medium	Long	Short	Long	Broad	Medium	Short	Medium	Deeply lobbed
<i>Panikarpooram</i>	Many	Long	Short	Long	Broad	Medium	Short	Medium	Deeply lobbed
<i>Pattanavella</i>	Many	Long	Short	Long	Medium	Medium	Medium	Medium	Deeply lobbed
<i>Poyya</i>	Many	Long	Short	Long	Broad	Medium	Short	Deep	Deeply lobbed
<i>Pramuttan</i>	Medium	Long	Short	Long	Medium	Medium	Short	Shallow	Moderately lobbed
<i>Thaikodi</i>	Medium	Long	Short	Long	Medium	Medium	Medium	Medium	Deeply lobbed
<i>Thulasi</i>	Medium	Long	Short	Short	Narrow	Medium	Short	Medium	Deeply lobbed
<i>Vellamunda</i>	Medium	Long	Short	Long	Medium	High	Short	Deep	Deeply lobbed
<i>Venmany</i>	Many	Long	Short	Long	Medium	Medium	Medium	Deep	Deeply lobbed

Nine quantitative morpho-anatomical characters were taken for a comparative study (Table 3 and Table.4). The cultivars can be broadly classified into two groups based on the number of adventitious roots: one having few numbers of adventitious roots and the other having many numbers of adventitious roots. All the cultivars have long Inter-nodal length with the exception of *Irujathikodi* and *Karpooram* both have medium inter-nodal length. Kerala cultivars differ from Northern cultivars in their internodal length, which is long and medium in the case of Kerala cultivars (Preethi *et al.*, 2016) All cultivars have short petioles and long leaf lengths, with the exception of *Karpooram*, which has medium leaf length and *Thulasi* has short leaves. Based on leaf breadth cultivars were fall into three categories i.e., broad medium and narrow. The cultivars are further grouped into short and medium lobe width, as well as medium, deep and shallow sinus depths. The discrete grouping of these cultivars is not possible due to the shared resemblances and differences in quantitative and qualitative traits; however *Karpooram*, *Thulasi* and *Selan* show some remarkable similarities in both quantitative and qualitative characters. Leaf length variation is short (rates from 7cm) Long (more than 14.5 cm) which is almost comparable to northern cultivars (Rahman *et al.*, 1997; Pariari & Imam 2000a). Similarly variation in leaf width range in between from 5.5-16.3cm in northern cultivars. Based on which were grouped into three groups, medium, narrow and broad. The betel cultivars of Madhya Pradesh predominantly have dark green coriaceous leaf with acute leaf tip, which also showed difference from Kerala cultivars.

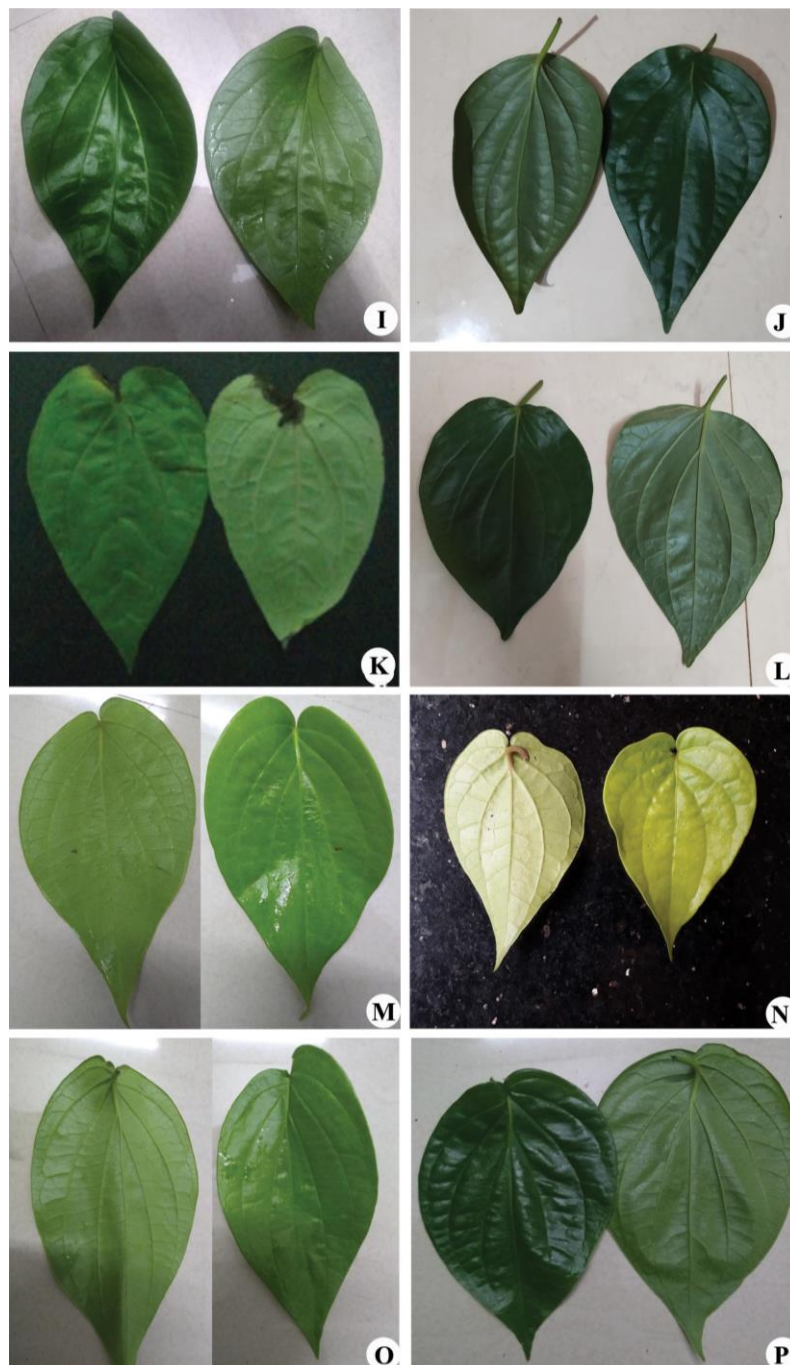


Plate 2: D orsal and ventral view of *P. betel* leaves I. Karpooram, J.Kootakodi K. Marakod, L. Nadankoli, M. Thaikodi, N. Thulasikodi, O. Pattanavella, P. Panikarpooram

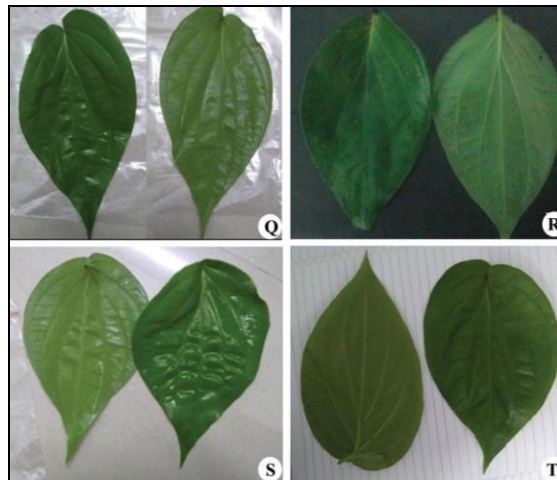


Plate 3: Dorsal of Ventral View of *P. betle* leaves. Q. Parmuttan, R. Poyya S. Vellamunda, T. Venmany

Acknowledgements

The authors are thankful to Mr Veerankutty, Selvaraj, Sasindran, Krishnakumar and Shamsudeen the traditional farmers in Kerala, for providing the plant materials for the present study and the Principal and Head of the Department of Botany, University College, Thiruvananthapuram, for providing facilities.

References

1. Guha P. Betel leaf: The neglected Green gold of India, *Journal of Human Ecology*,2006:19(2):87-93.
2. Guha P, Jain RK. Status Report on Production, Processing and Marketing of Betel leaf (*Piper betle* L.) Exploring Betel leaves for cottage industry, Agricultural and food engineering department IIT, Kharagpur India, 1997, 15-19.
3. Samantha C. A report on the Problems and Solutions of Betel vine cultivation, Hr.adhikari, C-2/16, Karunamiyee, Salt Lake City, Kolkatha-64(W/B) India, 1994.
4. Verma A, Kumar N, Ranade SA. Genetic diversity amongst landraces of a dioceous vegetatively propagated plant, betelvine(*Piper betle* L), *Journal of Bioscience*,2004:29(3):319-328.
5. Ranade SA, Verma A, Guptha M, Kumar N. RAPD profile analysis of betelvine cultivars., *Biol.Plant*,2002:45:523-527.
6. Sheet SK. Evaluation of betel vine (*Piper betle* L.) germplasm for quality, MSc(ag) thesis, Bidhan Chandrs Krishi viswa Vidyalaya, west Bengal,2002:120:12:2149-2156.
7. Lakshmi BS, Naidu KC. Comparative Morpho anatomy of *Piper betle* L. Cultivars of India, *Annals of Biological Research*,2010:1(2):128-134.
8. Sugumaran M, Gandhi SM, Sankarnarayanan K, Yokesh M, Poornima M, Rajasekhar SR. Chemical composition and antimicrobial activity of vellaikodi variety of Piper betle leaf oil against dental pathogens, *International Journal of Pharm Tech Research*,2011:3(4):2135-2139.
9. Senguptha K. Advances in Betel vine cultivation, National Seminar on Agriclture and Biosecurity in changing Scenario, Bidhan Chandrs Krishi viswa Vidyalaya, west Bengal, 2014, 56.
10. Rawath AKS, Balasubramanyam VR. In Proceedings of the National Workshop on Betel vine (Ray S C *et al*), The Agricultural Society of Indian, Culcutta, 1984.
11. Joseph K. Karyomorphological analysis in Piperaceae., JK publications, Ernakulam, 1990, 13.
12. Abraham.K., Study of bacterial leaf spot of betel vine-biochemical changes and control., Phd (Ag) Thesis, Kerala Agricultural University, 1986, 205P.
13. Preethy TT, Aswathi KK, Renisha Jayarajan Mannambeth, Asha V Pillai. Spectrum of variation in land races and different morphological characters of Betel Vine, *International Journal of Current Research*,2016:8(3):28164-28170.
14. Manoj P Raj, Karadka Ramdas Thilakchand, Princy L Palatty, Prathima Rao, Suresh Rao, Harshith P Bhat *et al.* *Piper betle* Linn(Betel Vine), the malignant South Asian Medicinal Plant Possesses Cancer Preventive Effects,: Time to Reconsider the Wronged Opinion, *Asian Pacific Journal of Cancer Prevention*, 2011.
15. Pariari A, Imam MN. Evaluation of Betel vine (*Piper betle* L.) cultivars in the gangetic alluvial plains of West Bengal, *Indian journal of spices and aromatic crops*,2012:21(1):1-8.
16. Rahman M, Das ND, Jana SC. Phenotypic stability for yield and yield attributes in betle vine (*Piper betle* L.), *Journal of plantation crops*,1997:25:189-192.
17. Parmar VS, Jain SC, Bisht KS, Jain R, Taneja P, Jha A *et al.* Phytochemistry of the genus *Piper*. *Journal of Phytochemistry*,1997:46:46:59.
18. Gamble JB, Flora of the Presidency of Madras, Botanical Survey Of India, Howrah, India,1928:2:(Rep.ed.1957).
19. Singh P, Betel vine, Publishers JK. West Bengal, 1994, 120p.