~~*Original Research Article*~~

Morphological diversity and growth parameters of fifteen betel vine varieties cultivated along the Odisha coast

ABSTRACT

Betel vine (Piper betle) is a tropical evergreen plant renowned for its cultural and medicinal significance. With origins in Southeast Asia, its heart-shaped leaves, vibrant colors and aromatic properties contribute to its widespread cultivation. The ~~present~~ study investigates the morphological diversity and growth parameters of fifteen betel vine variety cultivated along the Odisha coast, with a focus on vine elongation, leaf dimensions, internodal length, leaf area, weight of fresh leaves, number of adventitious root production and the number of leaves per meter of vine. The results revealed significant variation among the variety. Notably, vine elongation ranged from 39.5 to 68.8 cm/month, with the Golabandha variety showing the highest rate. Leaf length varied from 8.84 to 20.24 cm, and the Chandrakana variety displayed the longest leaves. Leaf breadth ranged from 4.46 to 15.3 cm, with the widest leaves found in Chandrakana variety. Internodal length varied from 3.06 to 6.46 cm, with Gunthuni having the lowest internodes. Leaf area ranged from 38.04 to 177.37 cm^2, with Chandrakana exhibiting the largest leaf area. Weight of fresh leaves varied significantly, with Chandrakana and Ralaba variety having the highest and lowest weights, respectively. Cluster analysis grouped variety based on their morphological characteristics, revealing distinct clusters related to leaf dimensions and growth parameters. Understanding the morphological diversity of betel vine variety is crucial for identifying the superior variety for sustainable cultivation and ensuring the quality of this culturally and economically significant crop.

Keywords: Betel vine, Cluster analysis, Morphological parameters, Odisha coast

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1. INTRODUCTION

Piper betle, commonly known as 'Pan,' is a member of the Piperaceae family. This evergreen and perennial creeper has its origins in Malaysia and is now cultivated across the globe [1]. It possesses notable ethnomedicinal importance and finds extensive usage in diverse Southeast Asian nations. Traditionally, the cultivation of this crop is predominant in Southeast Asian countries such as Taiwan, Malaysia, Thailand, Sri Lanka, and India. The betel vine has earned the title of the "green gold of India" due to its significance in the livelihoods of approximately 20 million individuals who are directly or indirectly involved in its production, processing, handling, transportation, and marketing within India [2]. Notable Indian states where betel vine is extensively grown include Odisha, Tamil Nadu, Madhya Pradesh, West Bengal, Maharashtra, and Uttar Pradesh[3]. It is commonly utilized in South Asia, often as betel quid or pan, frequently combined with areca nut or tobacco [4]. In Odisha's coastal districts like Balasore, Jagatsinghpur, Puri, Cuttack, Khordha, and Ganjam, betel vine is primarily grown [5]. However, India cultivates around 100 betel varieties, known as landraces, each named after the specific locality or region where they are cultivated [6]. Hence Betelvine cultivation encounters numerous challenges arising from the presence of synonymous terms. In certain areas, identical betel plants are grown under various names, while in other regions, distinct betel plants share identical names. As a result, variety carry the prefix 'Desi' in their names [7]. Hence, it is consistently challenging to distinguish between variety, often labelled with local names by the farmers. To enhance betel leaf production in the country, it is crucial to identify superior landraces or germplasm that can be used to develop high-yielding varieties of the crop. Based on the information provided, the current study was initiated to morphologically differentiate the variety cultivated along the Odisha coast.

2. MATERIAL AND METHODS

2.1 materialcollection

The farmers cultivate the betel vine in the betel vineyards which is locally known in the odia vernacular “Pana Baraja”. One such “Pana Baraja” has been established at F.M. University, Balasore Campus in which different varieties of betel vine cultivated among the farmers along the Odisha coast have been collected (Table 1). Hence the “Pana Baraja” of the F.M. university campus is practically working as a betel vine germplasm conservatory. The “Pana Baraja” is geographically located at 21º54’N latitude, 86º81’ E longitude and at an altitude of 17 m above MSL (Mean Sea Level). The experiment was conducted from August 2022 to August 2023. The morphological character like leaf length, leaf breadth, vine internode, petiole length and leaf area were evaluated by taking 10 randomly selected harvestable leaves from betel vine variety with 5 replications[8],[11].

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2.1 Description of study area
2.2 Experimental materials
2.3 Experimental design
2.4 Data collection procedure
2.5 Statistical analysis

2.2Statistical Analysis

One-way ANOVA was applied using Minitab 17 software to analyze all the data followed by the turkey HSD (Honestly Significance Difference) test which showed the variation in morphological characteristics of fifteen betel vine variety cultivated along the Odisha coast [9]. The data matrix consists of fifteen betel vine variety and eleven morphological characters of betel vine. Data within the row with different superscript letters were considered to be significantly different at $p < 0.05$. Hierarchical cluster analysis (HCA) was also carried out to assess the similarity and relationship between betel vine variety. Ward’s variance-minimizing method was used to evaluate the betel vine variety dissimilarity and hierarchical clustering by using Euclidean distance [10].

Table 1. The betel vine variety collected from different locations

Sl. No	Name of the Variety	Place of collection
1	Haldipan	Rampur Village, Purba Medinpur, West Bengal
2	Birkuli	Bhogarai, Balasore, Odisha
3	Chandrakana	Bhogarai, Balasore, Odisha
4	Aima	Baliapal, Balasore, Odisha
5	Nuagan pan	Paradeep, Odisha
6	Dhinkia pan	Paradeep, Odisha
7	Niali pan	Cuttack, Odisha
8	Golabandha	Berhampur, Odisha
9	Jugudi	Berhampur, Odisha
10	Ralaba	Berhampur, Odisha
11	Gunthuni	Puri, Odisha
12	Kakatpur Desi	Puri, Odisha
13	Bhainchigudi	Puri, Odisha
14	Balunga	Puri, Odisha
15	Mangalpur Desi	Puri, Odisha

Fig. 1. Outside and inside view of "Pana Baraja" at F.M. University Balasore

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Fig. 2. Morphological variations of leaves in different betel vine variety

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3. RESULTS AND DISCUSSION

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3.1 Vine Elongation

The vegetative growth parameters and morphological features of different variety of betel vine varied significantly (Table 2). The vine elongation in different variety of betel vine ranged from 39.5 to 68.8 cm/month. A maximum vine increment of 68.8 cm per month was recorded in the Golabandha variety followed by Chandrakana (56.3 cm/month) and Aima (55.7 cm/month) variety. The lowest vine increment of 39.5 cm was recorded in the Gunthuni variety followed by Ralaba (40.9 cm/month) and Jugudi variety (45 cm/month).

3.2 Leaf length

The variety showed significant variation concerning leaf length (Table 2) and the longest leaf (20.24 cm) was recorded in Chandrakana followed by Aima (20.04 cm) and Dhinkia (15.5 cm). The shortest leaf length was found in the Ralaba i.e., 8.84cm.

3.3 Leaf breadth

Significant variation in leaf breadth was observed among the variety (Table 2). The widest leaf (15.3 cm) was recorded in Chandrakana which was on par with Aima (15.26 cm). The shortest leaf breadth found in the Ralaba variety i.e.,4.46 cm.

3.4 Internodal length

The internodal length of 15 variety varied from 3.06cm to 6.46cm and was shorter in Gunthuni (3.06 cm) followed by Ralaba (3.74 cm) and Jugudi (4.26cm). A longer vine with a shorter internode is a desirable character in betelvine as it can produce a greater number of leaves due to an increase in the number of nodes. The longest internode was found in the Kakatpur Desi variety i.e.,6.46 cm.

3.5 Petiole length

The petiole length of 15 variety was varied from 2.3 cm to 7.34cm. Bhainchigodi recorded the longest petiole (7.34 cm) followed by Aima (7.26 cm) and Niali (7.26 cm) and the shortest petiole found in the Ralaba variety. A longer petiole can provide better positioning for the leaf in capturing sunlight, which enhances plant's overall energy production. Additionally, the petiole serves as a conduit for water and nutrients between the leaf and stem, contributing to the plant's nutrient uptake and distributions.

3.6 Leaf area

Significant variation in leaf area among the variety was recorded and the highest leaf area (177.37 cm^2) was recorded in Chandrakana followed by Aima (174.18 cm^2) and Nuagan pan (170.5 cm^2). The lowest leaf area was found in the Ralaba variety (38.04cm^2).

3.7 Weight of 100 fresh leaves

The fresh weight of 100 leaves varied significantly among the variety. Significantly higher fresh leaf weight (521.35g) was observed in the Chandrakana followed by Aima (499.20g) and Gunthuni (446.32g). The lowest fresh leaf weight was observed in Ralaba variety i.e., 70.07 g.

3.8 Adventitious root production

When a stem or leaf node of a betel vine comes into contact with a suitable substrate, it readily forms adventitious roots, aiding in vegetative propagation. This process ensures efficient clonal reproduction, making betel leaf cultivation easier. Additionally, adventitious roots enhance nutrient and water uptake, aiding plant establishment. The adventitious roots of all the variety varied from 2 to 10. The maximum number of adventitious roots found in the Chandrakana variety i.e., 10 followed by the Nuagan variety and the lowest number of adventious roots was found in Ralaba i.e., 2.

3.9 Number of leaves per meter of Vine

In ideal conditions, betel vines can produce a significant number of leaves, which are the most valuable part of the plant for various purposes, including traditional and cultural practices and medicinal applications. Significant variation in the number of leaves per meter of the vine was recorded which ranges from 13 to 24 and variety Gunthuni found a maximum of 24 leaves per meter of vine. Ideal conditions for higher leaf production in betel vines include longer vines with shorter internodes, as this configuration allows for more leaves to be produced from each node. Additionally, faster vine growth results in obtaining a greater number of leaves in a shorter time frame.

3.10 Morphological features of the betel vine variety

The betel vine variety varied remarkably in morphological characteristics viz. leaf colour, leaf apex shape, leaf softness and leaf lamina orientation along the midrib (Table 4). The evaluation of fifteen betel vine variety revealed that the betel leaf colour of the Haldi variety was yellowish green while the Mangalpur desi had dark green. The leaf apex shape of the Mangalpur desi variety was acute while the other variety were acuminate. Leaf lamina orientation along the midrib of all the variety was V-shaped. The proximity of the basal lobe in variety Niali and Kakatpur desi had closed and overlapped in the variety of Gunthuni, while other variety were separated. The leaf texture of Gunthuni, Kakatpur desi and Mangalpur desi was found coriaceous i.e., the leaf texture is thick and leathery while other variety of betel vine were found membranaceous i.e., the leaf texture is thin.

Table. 2. Variation in vegetative growth parameters of different betel vine variety grown in "Pana Baraja" at F.M. University Balasore

Variety Name	Vine elongation(cm)/month	Leaf Length (cm)	Leaf breadth (cm)	Petiole Size (cm)	Length of internode (cm)	Leaf Area (cm^2)
Haldipan	45.5 ± 2.11^{g}	14.2 ± 0.79^{cd}	12.52 ± 0.36^{c}	5.32 ± 0.11^{de}	5.13 ± 0.32^{cd}	145.81 ± 4.14^{cd}
Birkuli	52.1 ± 1.91^{de}	15.02 ± 0.76^{bcd}	12.26 ± 0.56^{c}	6.16 ± 0.11^{bc}	6.34 ± 0.39^{a}	140.21 ± 3.42^{de}
Chandrakana	56.3 ± 2.11^{b}	20.24 ± 0.83^{a}	15.3 ± 0.37^{a}	6.08 ± 0.13^{bc}	6.46 ± 0.49^{a}	179 ± 8.39^{a}
Aima	55.7 ± 2.60^{bc}	20.04 ± 0.56^{a}	15.26 ± 0.48^{a}	7.26 ± 0.18^{a}	6.14 ± 0.36^{ab}	167 ± 8.65^{ab}
Nuagan pan	52.0 ± 0.96^{de}	15.24 ± 0.17^{bc}	12.24 ± 0.19^{c}	6.5 ± 0.14^{b}	6.12 ± 0.54^{ab}	175.17 ± 9.81^{a}
Dhinkia pan	51.8 ± 1.54^{de}	15.5 ± 0.24^{b}	13.08 ± 0.16^{bc}	6.72 ± 0.15^{ab}	6.24 ± 0.73^{a}	148.70 ± 7.67^{cd}
Niali	49.1 ± 0.60^{ef}	14.42 ± 0.67^{bcd}	11.2 ± 0.35^{d}	7.26 ± 0.15^{a}	5.36 ± 0.89^{bcd}	168.17 ± 6.74^{ab}
Golabandha	68.8 ± 0.82^{a}	14.86 ± 0.24^{bcd}	8.04 ± 0.15^{e}	4.62 ± 0.30^{ef}	5.77 ± 0.99^{abc}	121.10 ± 5.55^{f}
Jugudi	45.0 ± 1.18^{g}	12.36 ± 0.45^{f}	8.08 ± 0.16^{e}	4.14 ± 0.11^{f}	4.26 ± 0.40^{ef}	69.21 ± 4.41^{g}
Ralaba	40.9 ± 0.79^{h}	8.84 ± 0.15^{g}	4.46 ± 0.17^{f}	2.3 ± 0.23^{g}	3.74 ± 0.51^{fg}	46.25 ± 5.25^{h}
Gunthuni	39.5 ± 0.66^{h}	15.36 ± 0.15^{b}	12.66 ± 0.15^{c}	6.36 ± 0.40^{bc}	3.06 ± 0.16^{g}	130.42 ± 4.61^{ef}
Kakatpur desi	50.5 ± 0.55^{de}	15.16 ± 0.17^{bc}	13.06 ± 0.52^{bc}	5.66 ± 0.71^{cd}	5.04 ± 0.82^{cde}	155.93 ± 6.70^{bc}
Bhainchigodi	52.9 ± 0.90^{cd}	14.96 ± 0.32^{bcd}	13.58 ± 0.87^{b}	7.34 ± 0.76^{a}	6.13 ± 0.78^{ab}	168.69 ± 8.85^{ab}
Balunga	52.4 ± 1.06^{de}	14.04 ± 0.11^{de}	12.22 ± 0.38^{c}	6.06 ± 0.19^{bc}	5.84 ± 0.70^{abc}	148.65 ± 6.23^{cd}
Mangalpur desi	46.4 ± 0.48^{fg}	13 ± 0.71^{ef}	10.82 ± 0.12^{d}	5.68 ± 0.16^{cd}	4.69 ± 0.64^{de}	136.16 ± 6.84^{def}

Data in the column with distinct superscript letters are significantly different using One way ANOVA followed by Turkey HSD test ($p<0.05$)

Values are represented in the form Mean ±S.D.

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Table. 3. Variation in vegetative growth parameters of different betel vine variety grown in "Pana Baraja" at F.M. University Balasore

Variety Name	Adventious root	Leaf depth of Sinus (cm)	Leaf lobe length (cm)	No. of Leaf/ meter of Vine	Weight of 100 fresh leaves with petiole(g)
Haldipan	7 ± 1.2^{de}	1.16 ± 0.05^{bcd}	4.44 ± 0.18^{bcd}	19 ± 0.55^{b}	393.35 ± 6.90^{efg}
Birkuli	7 ± 0.9^{de}	1.3 ± 0.07^{b}	5.08 ± 0.15^{a}	16 ± 0.55^{cd}	412.72 ± 6.57^{cde}
Chandrakana	10 ± 1.3^{a}	0.98 ± 0.08^{e}	4.16 ± 0.09^{d}	16 ± 0.71^{de}	519.13 ± 3.24^{a}
Aima	10 ± 1.0^{ab}	1.04 ± 0.05^{cde}	4.6 ± 0.12^{bc}	16 ± 0.84^{cde}	502.88 ± 5.73^{a}
Nuagan pan	11 ± 2.0^{a}	1.48 ± 0.08^{a}	5.12 ± 0.11^{a}	15 ± 0.55^{defg}	427.95 ± 8.84^{bc}
Dhinkia pan	6 ± 0.8^{e}	1.48 ± 0.08^{a}	2.32 ± 0.20^{f}	16 ± 0.45^{def}	415.57 ± 5.53^{cd}
Niali pan	6 ± 1.7^{e}	1.02 ± 0.08^{de}	4.34 ± 0.21^{cd}	16 ± 0.55^{defg}	376.33 ± 6.29^{g}
Golabandha	2 ± 0.5^{g}	0.7 ± 0.07^{f}	4.72 ± 0.20^{b}	15 ± 0.84^{defg}	223.57 ± 6.74^{i}
Jugudi	4 ± 1.0^{f}	1.48 ± 0.08^{a}	2.26 ± 0.11^{f}	17 ± 0.55^{bc}	376.51 ± 8.66^{fg}
Ralaba	2 ± 0.5^{g}	0.52 ± 0.08^{g}	2.74 ± 0.15^{e}	18 ± 0.55^{b}	73.64 ± 3.23^{j}
Gunthuni	7 ± 0.9^{cde}	1.48 ± 0.08^{a}	4.64 ± 0.11^{bc}	24 ± 0.55^{a}	447.07 ± 6.18^{b}
Kakatpur desi	7 ± 1.0^{de}	1.28 ± 0.08^{b}	4.26 ± 0.15^{d}	13 ± 0.45^{h}	395.96 ± 4.76^{ef}
Bhainchigodi	7 ± 1.7^{cde}	1.16 ± 0.09^{bcd}	4.46 ± 0.11^{bcd}	15 ± 0.55^{fg}	417.54 ± 6.36^{cd}
Balunga	9 ± 1.2^{bc}	1.2 ± 0.07^{bc}	4.48 ± 0.11^{bcd}	14 ± 0.55^{g}	402.57 ± 7.02^{de}
Mangalpur desi	8 ± 0.8^{bcd}	1.04 ± 0.05^{cde}	4.24 ± 0.11^{d}	15 ± 0.71^{efg}	283.98 ± 8.59^{h}

Data in the column with distinct superscript letters are significantly different using One way ANOVA followed by Turkey HSD test ($p<0.05$)

Values are represented in the form Mean ±S.D.

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Table.4.Physio-morphological featuresofthe different betelvinevariety cultivated in "Pana Baraja" at F.M. university Balasore

Variety Name	Leaf colour	Leaf Apex	Leaf Lamina Orientation	Proximity of Basal Lobe	Leaf texture
Haldipan	Yellowish green	Acuminate	V shaped	Separate	Membranaceous
Birkuli	Green	Acuminate	V shaped	Separate	Membranaceous
Chandrakana	Green	Acuminate	V shaped	Separate	Membranaceous
Aima	Green	Acuminate	V shaped	Separate	Membranaceous
Nuagan pan	Green	Acuminate	V shaped	Separate	Membranaceous
Dhinkia pan	Green	Acuminate	V shaped	Separate	Membranaceous
Niali pan	Green	Acuminate	V shaped	Close	Membranaceous
Golabandha	Green	Acuminate	V shaped	Separate	Membranaceous
Jugudi	Green	Acuminate	V shaped	Separate	Membranaceous
Ralaba	Green	Acuminate	V shaped	Separate	Membranaceous
Gunthuni	Light green	Acuminate	V shaped	Overlapped	Coriaceous
Kakatpur desi	Green	Acuminate	V shaped	Close	Coriaceous
Bhainchigodi	Green	Acuminate	V shaped	Separate	Membranaceous
Balunga	Green	Acuminate	V shaped	Separate	Coriaceous
Mangalpur desi	Deep green	Acute	V shaped	Separate	Membranaceous

Table. 5. Variation of morphological characters of different betel vine variety.

Sl. No.	Group	Morphological Characteristics
1	*Cluster Ia*	Leaf length (14.04-15.5 cm), leaf Breadth (11.2-13.58 cm), petiole size (7.34-5.66 cm), Internode size (3.06-6.34), No. of adventious root (6-11), Leaf area (130.42-175.17 cm^2), 100 fresh weights of leaf (393-447.07 g)
2	*Cluster Ib*	Leaf length (12.36 cm), leaf Breadth (8.08 cm), petiole size (4.14 cm), Internode size (4.26 cm), No. of adventious root (4), Leaf area (69.21cm^2), 100 fresh weights (376.51 g)
3	*Cluster Ic*	Leaf length (20.04-20.24 cm), leaf Breadth (15.26-15.3 cm), petiole size (6.08-7.26 cm), Internode size (6.14-6.46), No. of adventious root (10), Leaf area (167-179 cm^2), 100 fresh weights of leaf (412.72-519.13 g)
4	*Cluster IIa*	Leaf length (8.84-14.86 cm), leaf Breadth (4.46-10.82 cm), petiole size (2.3-5.68 cm), Internode size (3.74-5.77 cm), No. of adventious root (2-8), Leaf area (46.25-136.16 cm^2), 100 fresh weights of leaf (73.64-283.98 g)

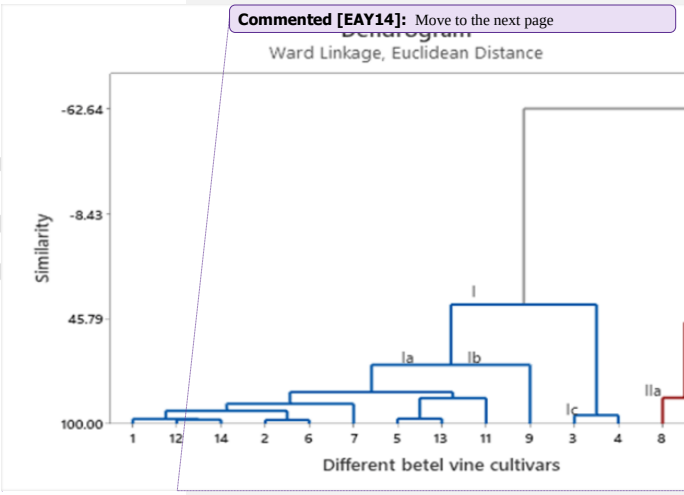

Fig. 3. Agglomerative Hierarchical Clustering (AHC) of fifteen betel vine variety based on morphological characters.

The relationships between the morphological characteristics of different betel vine variety cultivated along the Odisha coast were derived by HCA. The relationship among them was analysed based on the clustering pattern of the morphological characteristics of betel vine. The dendrogram obtained by HCA showed the morphological character and the Euclidean distance between the groups (fig. 3). The first main cluster (I) is again subdivided into three subcluster where the first subcluster (Ia) consist of variety 1,12,14,2,6,7,5,13 and 11; subcluster (Ib) consist of variety 9 while the subcluster (Ic) consist of variety 3 and 4. The second main cluster consists of variety 8,15 and 10. The first group (cluster I) represents the morphological characters like leaf length, leaf breadth, petiole size, and internode distance while the second group (cluster II) represents morphological characters like leaf area, leaf fresh weight and number of adventious root production as shown in (Table. 5).

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4. CONCLUSION

The ~~present~~ study conducted on fifteen different betel vine variety cultivated along the Odisha coast provides valuable insights into the morphological variations and growth parameters of this economically significant crop. The findings reveal considerable diversity among the variety. After meticulous evaluation, certain betel vine variety like Chandrakana, Gunthuni and Golabandha have emerged as superior performers in key parameters. Notably, Chandrakana displays larger leaf dimensions and fresh leaf weights while the variety Gunthuni and Golabandha show the maximum number of leaves per meter of the vine and maximum vine elongation per month respectively. The identification of superior variety provides valuable insights for farmers, allowing them to enhance their overall productivity and quality of betel vine cultivation along the Odisha coast. Environmental factors such as temperature, light intensity and soil quality were kept consistent throughout the cultivation process. This controlled environment ensures that observed differences in traits and characteristics are primarily influenced by genetic factors rather than differing growing conditions.

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ETHICAL APPROVAL

Not applicable.

CONSENT TO PARTICIPATE

Not applicable.

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